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Best Article Award

The ERS Administrator's Award for the Best Article in Agricultural Economics Research for the publication year ending April 1985 went to Douglas Gordon, formerly of the National Economics Division. He was honored at a ceremony on February 12, 1986, for his excellence in creative economic analysis and communication in the article, "Performance of Thin Futures Markets: Rice and Sunflower Seed Futures."

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In This Issue

One of the longer running and still ongoing controversies in economics divides economists into two camps. The first believes in the advantages of the market price system's working in decentralized competitive markets as an instrument for the allocation of resources and the imputation of income. The second is more apt to focus on imperfectly competitive markets and on the flaws in the price system and to see a need for public intervention in the market system. Most observers and participants in the controversy concur that the extreme points—either *laissez-faire* markets or centrally planned and controlled economies—are socially undesirable. Thus, the controversy is really over the proper mix of Government involvement in influencing the market. We have four articles in this issue dealing with different aspects of Government involvement in the agricultural economy.

In the lead article, Salathe and Langley explore alternatives for public intervention in wheat markets. These alternatives include using the executive power of Government to segment domestic and foreign markets and using the spending and taxing power of Government to transfer income to wheat producers, divert land from wheat production, and store grain diverted from the open market. Thus, Salathe and Langley analyze direct Government intervention in income distribution, land use, and supply availability.

The second article, by Hrubovcak, analyzes the effect of Government tax policies on the cost of capital to the farm sector. The type of Government intervention analyzed in this article is a more subtle, yet important, influence on the underlying capital cost structure of agriculture. This influence can affect both the longrun capacity of the sector and the nature of agricultural production.

The third article, by Musser and others, discusses a third role of Government in agriculture. The researchers note that what they believe is a socially preferable production practice is not used by all producers. They report results of a survey of users, past users, and nonusers of the practice and attempt to identify differences in perception of the practice among the three groups. A valid role of Government might be to use these results to design an educational program addressing gaps in information that contribute to the lower level of use of the practice perceived as socially preferable. An interesting finding of the survey was that perception of profitability of the practice differed among groups. The users thought it was profitable to do so. The nonusers did not—a rather normal response to perceived market signals.

In the fourth article, Paarlberg and Webb remind us how recent vulnerability of the farm sector to macroeconomic forces is more nearly the historical norm than was the period in the fifties and sixties, when Government commodity programs and international exchange policies partially insulated the farm sector from these forces.

Just as the continuing controversy in economics on the proper role of Government in a market economy has a long history, so does the study of the role of Government in agriculture. The authors in this issue have contributed to a rich tradition of studies.

Gerald Schluter

Contents

An Empirical Analysis of Alternative Export Subsidy Programs for U.S. Wheat

Larry Salathe and Suchada Langley*

Abstract

U.S. wheat exports have fallen nearly 20 percent since 1981. Major contributing factors appear to be the strong U.S. dollar, debt problems in many grain-importing countries, and mandated support levels providing an umbrella under which U.S. competitors can produce and sell their grains. U.S. subsidies for wheat sales abroad, either directly or by segmenting the domestic and export markets, might offset these factors. This article analyzes the consequences of several export subsidy programs on U.S. producers, consumers, and taxpayers under alternative assumptions regarding the price responsiveness of the world wheat market.

Keywords

Farm programs, international trade, export subsidies, two-price program, wheat

Introduction

U.S. wheat exports have stagnated in recent years. Major contributing factors appear to be a strong dollar and debt problems in many grain-importing countries (*12*).[1] The U.S. wheat loan rate has also kept the U.S. wheat price from falling to market-clearing levels, further reducing the *competitiveness* of U.S. wheat abroad. Some economists argue that the U.S. Government should reduce the cost of U.S. wheat to foreign buyers through direct subsidies or should segment its domestic and export markets using a so-called "two-price" program. This action would reduce the negative effects of relatively high loan rates on U.S. grain exports and still maintain price and income support to farmers. Such programs originally surfaced during the twenties as a way to hold the U.S. price above the world price level, thus enabling farmers to receive a fair market return (*8*). Simply put, export subsidy programs artificially raise the price of grain sold for domestic consumption and lower the price of grain sold to export markets. Thus, domestic grain consumers are taxed whereas foreign consumers receive a subsidy.

Proponents of subsidy programs point out that such programs increase the competitiveness of U.S. grain in international markets, thereby expanding exports and placing additional pressure on the European Community (EC) to reform its agricultural policies. Because the domestic market for U.S. grains is less responsive to changes in market price than is the international market, subsidy proponents also suggest that such programs might be used to increase farmers' net returns and simultaneously reduce Government outlays for price and income support.

However, export subsidy programs have serious negative aspects. As already indicated, these programs increase the price of grain domestically. Consumers pay higher prices for grain-based food products. And, competitor countries would probably view such a program as a major effort by the United States to restrict free trade. Some might retaliate by instituting trade barriers or by increasing export subsidies on either or both agricultural and nonagricultural (such as steel and textile) goods. At a minimum, the United States could lose some of its ability to pressure other countries to reduce trade barriers.

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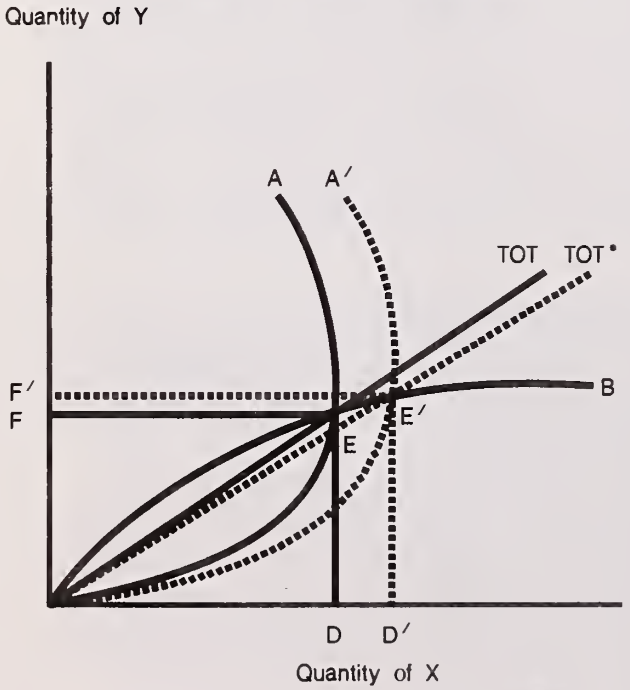
[1]Italicized numbers in parentheses refer to items in the References at the end of this article.

The purpose of this article is to analyze the effects of two alternative export subsidy programs on domestic wheat producers, consumers, and taxpayers. The first alternative is simply a Government export subsidy paid on each bushel of wheat sold for export. The second program would establish a high support price on wheat sold for domestic food use and a much lower support price on wheat sold for export and nonfood domestic uses.

Theoretical Foundations

Assume that the shortrun objectives of an export subsidy program are to raise domestic producer prices and incomes. Let us begin by assuming there are two countries, A and B, and two commodities, X and Y. These assumptions are easily modified without loss of generality. Country A exports X (with domestic and international prices being P_x^d and P_x, respectively) and imports Y (with prices being P_y^d and P_y). Country B imports X and exports Y. Although the pattern of trade could change over time, assume that a fixed pattern holds for the trading world at any point. The figure displays the free-trade and trade subsidy equilibrium.

Trade Equilibrium for Export Subsidies



The curve OA is country A's free-trade offer curve. The shape of the curve is characterized by the increasing opportunity cost of commodity X's production (*1*). OB is country B's free-trade offer curve. Point E, where OA intersects OB, is the free-trade equilibrium. The slope of the straight line, TOT, is the terms of trade in the free-trade world. By providing an export subsidy on commodity X, A's offer curve (subsidy-distorted offer curve) shifts to the right of E. OA′ is the new offer curve for country A under a trade subsidy program. The new equilibrium is E′ where country A is willing to trade OD′ of commodity X for OF′ of commodity Y. TOT*, the new terms of trade, is lower from country A's point of view, but is higher from country B's. Thus, country A has to give up more units of X for each unit of Y than before the subsidy, and the subsidy lowers the world price of X in terms of Y (P_x/P_y). The welfare of country B increases while A's decreases because country A's consumers will pay more for X while country B's consumers will pay less.

The overall results appear contradictory. In terms of domestic welfare, the subsidizing exporter suffers a net welfare loss, although the volume of exports expand. However, the loss in net welfare may decline if the export subsidy is not applied uniformly to all countries (*16*).

In a multicountry world with many importers and exporters, a per-unit subsidy will cause importers to expand their import volume as the subsidy lowers the world price. The subsidizing exporter expands exports at the expense of other exporting countries. The degree to which world prices fall and the export volume of the subsidizing country expands will depend on the level of the subsidy and the responsiveness (elasticities) of demand and supply in importing and exporting countries to changes in world prices, assuming, of course, that other exporters do not retaliate.

Now let us consider more closely the effects of an export subsidy on the U.S. wheat market. For simplicity, assume that there are two markets for U.S. wheat: the domestic market, which we characterize as highly price inelastic, and the export market, which we assume is considerably more responsive to price changes.

If demand in each market is characterized by the following equation:

$$Q_i = a_i - b_iP_i \qquad i = 1,2 \qquad (1)$$

where i = 1 is the domestic demand for wheat and i = 2 is the export demand for wheat, then total sector profits (TP) is given by:

$$TP = P_1Q_1 + P_2Q_2 - C(Q_1 + Q_2) - FC \qquad (2)$$

where C represents variable cost per unit of production and FC represents total fixed costs. Solving equation (1) for P_i and substituting the result into equation (2), one obtains the following expression for total profits:

$$\begin{aligned} TP &= Q_1(a_1 - Q_1)/b_1 \\ &\quad + Q_2(a_2 - Q_2)/b_2 - C(Q_1 + Q_2) - FC \end{aligned} \qquad (3)$$

The first-order conditions for profit maximization are:

$$\partial TP/\partial Q_1 = (a_1 - 2Q_1)/b_1 - C = 0 \qquad (4)$$

$$\partial TP/\partial Q_2 = (a_2 - 2Q_2)/b_2 - C = 0 \qquad (5)$$

Or, equivalently:

$$(a_1 - 2Q_1)/b_1 = (a_2 - 2Q_2)/b_2 \qquad (6)$$

Equation (6) states that a monopolist who practices price discrimination will maximize profits by setting the marginal revenue in each market equal to the marginal cost of production. Furthermore, a monopolist selling in more than one market will maximize profits by setting a higher price in the market which exhibits the lower demand elasticity.

Because the domestic wheat market is generally less responsive to price change than the export market, wheat producers' profits would tend to increase if these two markets were segmented with a higher price charged to domestic consumers. Higher returns to producers, in turn, suggest that Government outlays for price and income support might decline, thereby easing the burden on taxpayers. Of course, if a high support price is set on wheat sold domestically, consumers would pay higher prices; however, consumers are also taxpayers. If exports are subsidized directly, farmers' incomes rise and the decline in Government outlays resulting from lower deficiency and diversion payments may offset the cost of the export subsidy.

At what level should domestic and export prices be set? Equation (6) indicates that the marginal revenue in each market should equal marginal cost. For example, variable expenses per bushel for wheat in 1983 averaged $1.41, total domestic use equalled 1.111 billion bushels, and exports totalled 1.429 billion bushels (*18*). The average price received in 1983 was $3.53 per bushel. If we further assume that the own-price elasticity of demand for wheat used domestically is −0.20, then the domestic demand function for wheat can be characterized by the following equation:[2]

$$Q_1 = 1333.21 - 62.95P_1 \qquad (7)$$

By substituting the above values for a_1 and b_1 in equation (6), we obtain:

$$\frac{(1333.21 - 2Q_1)}{62.95} = 1.41 \qquad (8)$$

$$2Q_1 = 1244.45 \qquad (9)$$

$$Q_1 = 622.23 \qquad (10)$$

By substituting the value of Q_1 into equation (7) and solving for price, we obtain:

$$622.23 = 1333.21 - 62.95P_1 \qquad (11)$$

$$62.95P_1 = 710.98 \qquad (12)$$

$$P_1 = 11.29 \qquad (13)$$

Thus, a profit-maximizing, price-discriminating monopolist would set the domestic price of wheat at $11.29 per bushel and would market 622 million rather than 1.111 billion bushels domestically.

We can derive corresponding quantities and prices for the export market. Past studies, however, provide a wide range of elasticity estimates for U.S. wheat exports. Rather than selecting one particular value, we steadily increase the export elasticity from 0.25 to 4.00. Table 1 shows the corresponding quantities exported and the export price.

[2]Assuming a linear demand function reasonably approximates the true functional relationship between domestic use and price.

Table 1—Price discriminating export quantities and prices

Item	Unit	Export elasticities				
		−0.25	−0.50	−1.00	−2.00	−4.00
Price	Dollars per bushel	9.53	6.00	4.24	3.35	2.91
Quantity	Million bushels	821.80	929.00	1,143.60	1,572.70	2,430.90

The results in table 1 indicate that the export elasticity would have to be approximately 2.00 in the short run before a price-discriminating monopolist would set the export price below $3.53 per bushel, the average farm price for the 1983/1984 crop year. Most past studies indicate that the wheat export elasticity is less than 1.00; thus, a price-discriminating monopolist would set a higher price than $3.53 per bushel in both domestic and export markets (table 2). This situation contrasts with current two-price proposals which involve lowering the support price (below current levels) for wheat for export to increase U.S. competitiveness in world markets.

Theory provides little clue as to whether farmers would be better off if a two-price program included a higher domestic price coupled with a lower export price. We have also ignored losses in transfer payments that could result from stronger domestic prices.

Empirical Model

We used a computer simulation model of the U.S. wheat sector to measure the effects of alternative export subsidy programs for U.S. wheat. The model consists of 39 equations to estimate wheat production, use, price, Commodity Credit Corporation (CCC) loan activity, farmers' gross and net income, consumer expenditures for wheat products, and Government wheat program outlays.

The computer simulation model was developed for use on a personal computer compatible with the Lotus 1-2-3 software. This software solves the simultaneous equation model using policy variables and assumed intercept and slope coefficients as input data for each supply and use function. All functions are linear in parameters, but the flexibility exists to change assumed intercept and slope coefficients each year during the simulation period, thereby allowing the user to analyze alternative policies over a range of various elasticity estimates for supply and use. The default response coefficients in the model stem from past empirical studies of the U.S. wheat sector including previous computer modeling efforts such as FAPSIM (*15*) and WHEATSIM (*10*). We also estimated several functional relationships to update and provide information on response coefficients generally not included in past studies.

Supply

We determined the total supply of wheat by summing production, imports, and beginning stocks. Wheat imports are negligible and treated as exogenous. Beginning stocks equal previous-year ending stocks, and production equals acreage harvested times yield per harvested acre.

We specified acreage harvested as a linear function of acreage planted and yield per harvested acre as a function of acreage planted and acreage set aside and diverted. We assumed acreage planted is related to both market and Government program incentives. Program incentives include target price, loan rate, diversion payment rate, and the proportion of land which must be diverted from production. We also assumed the basis for a farmer's production decision is the return over variable cost of production.

We assumed that the decision to participate in an announced Government acreage reduction program

Table 2—Elasticities of supply and demand for U.S. wheat

Author	Date period	Supply	Food demand	Feed demand	Export demand
		Elasticities			
Blakeslee (*2*)	1954-74	0.047-.188	−0.012	−2.11	−2.00-−3.56
Bredahl, Meyers, Collins (*3*)	NS	—	—	—	0-−1.67
Cochrane, Danin (*4*)	1950-73	—	−.370[1]	—	−.50
Salathe, Price, Gadson (*15*)	1962-79	.290	−.070	−1.49	−.54
Fox (*6*)	1929-53	—	−.067	—	−.50
Gallagher, Lancaster, Bredahl, Ryan (*7*)	1955-75	.510[2]	—	−3.29	−.41
Honma, Heady (*11*)	1968-81	.350	−.200	—	−.44
Longmire, Morey (*12*)	NS	.200	−.400[3]	—	—
Matthews (*13*)	1954-70	—	−.150	—	−.35
Morton, Devados, Heady (*14*)	1960-79	.098	—	−1.73	−.14
Tweeten, Kalbfleisch, Lu (*17*)	NS	—	−.046-−.060	−.56	−.50
Zwart, Meilke (*19*)	1953-74	.090	−.100	—	—

NS = Not specified.
— = Not available.
[1]Total domestic demand.
[2]Winter wheat only.
[3]Total wheat demand.

is determined by the difference in expected returns between participation and nonparticipation. Multiplying the market price for the previous year by the farmer's yield expectation and subtracting variable costs of production provides the estimated expected return from nonparticipation. We estimated yield expectation using a moving average of yields for the previous 5 years excluding the lowest and highest yields. The expected return from participating in an announced acreage reduction program is a function of target price, loan rate, expected market price, expected yield, diversion payment rate, program yield, and the amount of land to be idled (*15*).

Acreage planted is a linear function of the expected program and market returns and acreage set aside and diverted. We hypothesized that an increase in expected market and program returns provides an incentive to plant additional acreage. The model's default coefficients assume that each $10-per-acre increase in expected returns increases planted acreage by 1.5 million acres, implying a price elasticity of 0.22 with respect to acreage. We assume acreage planted would decline by 0.67 of an acre for each 1-acre increase in acreage set aside and diverted, a slippage factor of 0.33 which corresponds to earlier studies (*5, 15*).

Use

The computer simulation model estimates food and industrial use, seed use, feed use, exports, and ending stocks. Ending stocks consist of three components: farmer-owned reserve, CCC stocks, and free stocks. Food and industrial use, exports, and feed use are linear functions of price. Past studies generally indicate that food and industrial use is highly price-inelastic whereas feed use is price-elastic (table 2). However, there is little consensus about the responsiveness of U.S. wheat exports to changes in price. The default slope coefficients in the model assume elasticities (based on 1984 crop year estimates) of −0.07, −1.05, and −0.45 for food and industrial use, feed use, and exports, respectively.

We patterned the functional relationships for farmer-owned reserves, CCC stocks, and free stocks after those in FAPSIM (*15*). Free stocks are a function of price and the level of farmer-owned reserve stocks. The model assumes that each 1-bushel increase in reserve stocks would reduce free stocks by 0.3 bushel.

We assumed that wheat placed in the farmer-owned reserve would remain in the reserve for 5 years unless market price equals or exceeds the reserve release price. If price fails to reach the release level during the 5-year period, reserve placements would default to the CCC. If price exceeds the release price during the contract period or the loan rate plus interest charges at the end of the contract period, reserve stocks become available to the open market.

CCC stocks consist of stocks acquired by the Government through price-support programs. We assumed that CCC stocks would accumulate as farmers default on reserve and regular CCC loans. CCC stocks are available to the open market only when the market price exceeds the reserve release price by 5 percent.

Loan Activity

The model predicts price-support loan activity based on market price, loan rate, and CCC interest charges. The loan activity component of the model consists of five equations. The first, beginning outstanding loans, equals the sum of outstanding reserve and regular CCC loans at the beginning of the crop year. Loan placements are based on an econometric relationship and are a function of the market price and the loan rate. If price is between the CCC loan rate and the release price, each 10-percent increase in the market price relative to the loan rate reduces total loan placements by 76 million bushels.

Total loan repayments consist of reserve loan and regular 9-month loan repayments. We assumed that farmers will repay outstanding loans at the beginning of the crop year if price exceeds the loan rate plus interest charges. If price fails to exceed the loan rate plus interest charges, outstanding loans would default to the CCC. We then added the quantity of grain defaulted to the CCC to existing CCC stocks.

Market Price

We determined the market price of wheat by solving the supply-demand equilibrium condition for price. For example, total supply is predetermined at the beginning of the crop year. The equilibrium price is that price which equates total supply and total use plus ending stocks. Because all use equations and ending stocks are linear in price, we can solve these equations to determine that price which uniquely equates supply and demand.[3]

Market price can be altered by Government reserve and CCC stock programs. For example, the reserve may act to hold prices at the release level when supply is low relative to demand. To account for such policies, we used decision rules to adjust market prices in situations when price is estimated to exceed the release level or to fall below the loan rate. First, we assumed that the 9-month regular loan generally acts as a price floor and the minimum market price thus becomes the loan rate. Second, as mentioned earlier, we assumed that reserve and CCC stocks would be placed back on the open market when prices reach their corresponding release

[3]Under the $7.00 (domestic price)/$2.50 (export price) and $10.00/$2.50 two-price programs analyzed in this study, we calculated the equilibrium market price by first estimating the level of food and industrial use, by subtracting that figure from the total available supply, and by then determining that price which uniquely equates the reduced available supply and total demand less food and industrial use.

levels. Under this situation, the market price equals the release price, and the market price does not exceed the release price unless total reserve or CCC stocks are depleted.

Income Indicators

The model estimates the change in farmers' net income resulting from a change in Government policy. The model estimates farmers' gross income by summing the value of production (price times production), deficiency payments, diversion payments, and reserve storage payments. We calculated deficiency payments by multiplying the difference between the target price and the maximum of the loan rate and the 5-month market price by the participation rate, program yield, base acreage, and 1 minus the set-aside and diversion rate. We estimated diversion payments by multiplying the diversion payment rate by the program yield, base acreage, and proportion of land diverted from production. We determined storage payments by multiplying the level of reserve stocks by the reserve storage payment rate per bushel. Farmers' net income is calculated as gross income minus variable production expenses per planted acre times planted acreage.

Net CCC Outlays

We estimated CCC loan outlays by subtracting the basis. We derived these estimates by allocating crop-year loan activity and Government payments between fiscal years. The model endogenously estimates both Government payments and changes in CCC loan activity. Government payments consist of deficiency, diversion, and reserve storage payments. We estimated CCC loan outlays by subtracting the value of loan placements (loan placements times the current loan rate) from the value of loan repayments. An additional cost to the Government is the cost of storing and handling existing CCC stocks. We calculated this outlay by multiplying the average CCC stock level by a fixed cost per bushel for storage and handling.

Consumer Expenditures

We estimated consumer expenditures for bakery products by multiplying the farm price by the quantity of wheat used for food and industrial use plus marketing, processing, and transportation costs.[4] We assumed that costs beyond the farm gate would increase at about the rate of inflation during the study period and would remain unaffected by changes in wheat export programs.

Baseline Assumptions

We simulated each export program over the crop year period from 1985/86 through 1991/92. Thus, the simulated impacts are conditional upon assumptions regarding demand growth, productivity, and agricultural policies and programs.

Current agricultural legislation expired in 1985. Rather than attempt to out-guess the Congress, we assumed future legislation would not be radically different from current farm policies and programs. That is, the Secretary of Agriculture would still have the authority to implement acreage reduction and land diversion programs if needed. We assumed that target prices and loan rates would be mandated at minimum levels of $4.38 and $3.30 per bushel, respectively, for 1986/87 through 1991/92, the same as in 1984/85 and 1985/86. We assumed that the diversion payment rate and farmer-owned reserve storage payment rate would remain at $2.70 and $0.265 per bushel throughout the simulation period.

We assumed that productivity would continue to grow at the pace of the past decade. Wheat yields per harvested acre are forecast to increase by about 0.6 bushel per acre per year. Food and industrial use should increase with population growth, rising from about 650 million bushels in 1985/86 to about 700 million bushels in 1991/92. Seed use should remain at about 90 million bushels throughout the simulation period, reflecting the expectation of minimal growth in wheat acreage from 1985/86 through 1991/92. Feed use will average about 255 million bushels over the period, declining from 1984/85 levels as the price of corn declines from its drought-heightened 1983 level to a more normal relationship with wheat. Wheat export growth will likely be considerably below that of the seventies.

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[4]Under the $7.00/$2.50 and $10.00/$2.50 program alternatives, we substituted the domestic support price for food and industrial use for the farm price when calculating consumer expenditures for bakery products.

We expect wheat exports will remain steady at about 1.3 billion bushels for 1985/86 through 1987/88 and then steadily rise to slightly over 1.4 billion bushels for 1991/92. This forecast assumed that the dollar will remain strong in world markets with slow economic growth and a continuation of debt-financing problems in many less-developed countries. We also assumed the United States will continue current export credit guarantee and export promotion programs at about the same funding level as in fiscal year 1984.

Given these assumptions, an initial simulation indicated that ending stocks would remain large in relation to historical levels and that wheat prices would remain depressed throughout the 1985/86 to 1991/92 period in the absence of a land retirement or an expanded export program. We, therefore, assumed the Secretary will announce an acreage reduction program to cut supplies, strengthen prices, and reduce CCC program outlays. Under the baseline, the 20-percent acreage reduction and 10-percent paid land diversion program announced for 1985 is continued through 1991/92. This program removes about 20 million acres from production each year. Despite the placement of about 20 million acres in conserving use each year, ending wheat stocks grow from about 1.5 billion bushels in 1985/86 to over 3 billion bushels by the end of the 1991/92 marketing year. The average farm price of wheat increases moderately under the baseline policy scenario from $3.30 per bushel in 1985/86 to about $3.37 per bushel in 1991/92. CCC net outlays under the baseline average over $4.2 billion per year with over half the outlays being in the form of deficiency and diversion payments.[5]

Empirical Analysis

We analyzed two types of export subsidy programs. Because of the wide range of elasticity estimates for U.S. wheat exports, we ran each program with the export elasticity ranging from −0.25 to −4.00. We chose this range to provide information on the likely effects of each program alternative and on the sensitivity of the estimates to the choice of the export elasticity.

[5]This baseline is used only for comparison and does not represent official USDA estimates.

We conducted a total of five simulations. The first simulation assumes a direct subsidy of 50 cents per bushel on each bushel of wheat for export, and the second assumes a direct subsidy of $1 per bushel. The third assumes a direct subsidy of $1.50 per bushel coupled with elimination of production controls. The final two simulations also assume elimination of production controls with the Government's setting a $7 and $10 per bushel support price for wheat for domestic food and industrial use, respectively. In these final two simulations, we set the support price for wheat for export and other domestic uses at $2.50 per bushel; the program would be financed by taxing wheat processors.

Export Subsidy of 50 Cents per Bushel

The simulation results indicate that compared with the baseline, a 50-cent-per-bushel subsidy on each bushel of wheat for export would increase U.S. wheat exports, farm prices, and wheat production.[6] Assuming wheat exports have an elasticity of 0.5, farm price would increase by 10 cents per bushel on average for crop years 1985/86 to 1991/92 (table 3). Harvested acreage would increase on average by less than 1 million acres, production by about 20 million bushels, and exports by about 85 million bushels. Ending stocks would average about 215 million bushels lower over the simulation period. Compared with the baseline, farmers' gross income would average about $80 million higher, CCC net outlays about $240 million higher, and consumer expenditures about $65 million higher.

A closer examination of the results in table 3 reveals that, as the export elasticity increases, farm price and farmers' incomes rise, CCC net outlays fall, and consumer expenditures increase. A 50-cent-per-bushel export subsidy would increase farmers' incomes even when the export elasticity is assumed to be below 1, because higher farm prices more than offset the decline in income resulting from lower deficiency payments.

Although farmers' gross and net incomes would be higher, CCC net outlays would not fall below their

[6]For over 50 years, U.S. wheat export subsidies ranging from 1 to 95 cents per bushel were paid to grain export companies. Subsidy payments ended in September 1972 when the U.S. price came into line with the world market price (*9*).

Table 3—Effects of an export subsidy of 50 cents per bushel[1]

Item	Unit	Baseline	Export elasticities				
			−0.25	−0.50	−1.00	−2.00	−4.00
Acreage planted	Million acres	72.52	72.96	73.33	73.74	74.05	74.53
Acreage harvested	do.	65.27	65.66	66.00	66.37	66.65	67.09
Yield per acre	Bushels	41.00	40.91	40.84	40.77	40.71	40.63
Supply:	Million bushels						
Beginning stocks	do.	2,183.07	2,085.62	2,019.77	1,914.82	1,680.12	1,276.60
Production	do.	2,674.25	2,685.67	2,695.16	2,705.43	2,712.99	2,725.39
Imports	do.	3.00	3.00	3.00	3.00	3.00	3.00
Total	do.	4,860.32	4,774.29	4,717.93	4,623.25	4,396.11	4,004.99
Use:							
Food and industry	do.	678.99	678.26	677.74	676.89	676.40	675.52
Seed	do.	91.21	91.74	92.20	92.71	93.08	93.67
Feed	do.	254.80	248.52	243.96	236.61	232.38	224.81
Exports	do.	1,382.14	1,427.86	1,464.83	1,519.29	1,624.25	1,749.39
Total	do.	2,407.15	2,446.39	2,478.74	2,525.49	2,626.11	2,743.39
Ending stocks	do.	2,453.18	2,327.19	2,239.19	2,097.96	1,770.00	1,261.59
Price	Dollars per bushel	3.33	3.39	3.43	3.50	3.54	3.61
Income indicators:	Million dollars						
Value of production	do.	8,909.74	9,105.01	9,249.30	9,468.60	9,600.20	9,837.87
Deficiency payments	do.	1,920.07	1,799.29	1,702.80	1,565.55	1,477.47	1,324.47
Storage payments	do.	152.41	145.32	141.14	136.09	130.89	124.29
Diversion payments	do.	789.26	772.08	757.39	741.44	729.47	710.60
Total gross income	do.	11,771.47	11,821.70	11,850.62	11,911.67	11,938.03	11,997.23
Variable expenses	do.	4,485.36	4,512.57	4,535.46	4,560.82	4,579.99	4,609.68
Total net income	do.	7,286.11	7,309.12	7,315.16	7,350.85	7,358.04	7,387.55
Net CCC outlays:[2]							
Deficiency payments	do.	1,770.90	1,657.17	1,556.50	1,450.01	1,356.59	1,225.60
Diversion payments	do.	791.69	773.94	759.59	740.94	727.22	708.82
Storage payments	do.	150.33	143.21	139.03	134.49	129.09	123.13
Net lending	do.	931.41	829.26	748.69	609.87	290.67	−61.22
Export subsidy	do.	0	712.18	729.95	758.37	809.88	873.08
Other	do.	558.37	530.81	509.83	472.16	370.44	190.49
Total	do.	4,202.69	4,646.57	4,443.60	4,165.84	3,683.90	3,059.89
Consumer expenditures[3]	do.	37,783.45	37,821.71	37,847.06	37,891.53	37,916.87	37,961.04

[1]Unless indicated otherwise, numbers are crop year 1985/86 to 1991/92 averages.
[2]Fiscal year 1986-91 averages.
[3]For bakery products.

baseline value unless the export elasticity is nearly 1. Thus, the export elasticity must be nearly 1 before the cost of the export subsidy would be more than offset by Government savings from lower deficiency, storage, and diversion payments and from lower CCC net loan activity and storage costs. If the cost of supporting farmers' incomes is calculated as the change in CCC net outlays and consumer expenditures, the export elasticity must be above 1 before the total cost of supporting farm income would fall below its baseline value.

The simulation results suggest that farmers' incomes, CCC net outlays, and consumer expenditures do not vary greatly from their baseline values despite the wide range for the export elasticity. Assuming an export elasticity of 2, farmers' gross income less variable expenses would average less than 1 percent higher ($72 million), CCC net outlays less than 13 percent lower ($519 million), and consumer expenditures less than 1 percent ($133 million) higher than their respective baseline values.

Earlier we stated that economic theory indicates that the subsidizing exporter suffers a net welfare loss. The results, however, suggest that, for some values of the export elasticity, an export subsidy could result in net benefits to society as taxpayer savings plus increases in farmers' incomes exceed increases in consumer costs. At first glance, the results appear inconsistent with economic theory. However, economic theory generally begins with the assumption of perfect competition or no Government intervention and then measures the effects of a change in policy on consumers, taxpayers, and producers. But, the baseline from which the effects of each program are measured assumes that the Government will intervene in the wheat market by implementing acreage reduction and paid land diversion programs and by providing income and price protection to producers by setting target prices and loan rates. This basic difference in the policy environment from which the export subsidy effects are measured explains why our results differ from those generated under the assumption of perfect competition or no Government intervention.

Export Subsidy of $1 per Bushel

Assuming a subsidy of $1 per bushel rather than 50 cents will increase wheat farmers' gross income at each value of the export elasticity (table 4). If the export elasticity equals 0.5, a $1-dollar-per-bushel export subsidy would increase wheat exports on average by nearly 170 million bushels, the price of wheat by 18 cents per bushel, and wheat farmers' gross income less variable expenses by nearly $68 million. Compared with the baseline, CCC net outlays average $594 million per year higher and consumer expenditures increase by nearly $115 million per year if the export elasticity equals 0.5.

Again, CCC net outlays fail to decline below their baseline value unless the export elasticity is nearly 1. However, if the total cost of supporting farmers' incomes is calculated as the change in both CCC net outlays and consumer expenditures, the total cost of supporting farmers' incomes would exceed its baseline value unless the export elasticity is above 1. Assuming an export elasticity of 4, farmers' net income would average $397 million per year higher (or about 5.4 percent above its baseline value), CCC net outlays about $1,140 million lower (27.1 percent), and consumer expenditures for bakery products about $434 million higher (1.1 percent).

Export Subsidy of $1.50 per Bushel and No Production Controls

In an attempt to reduce CCC net outlays, one alternative is to eliminate production controls and thereby to eliminate deficiency and diversion payments. In fact, some analysts argue that production controls reduce U.S. competitiveness in world markets as competitor countries expand production while the United States simultaneously idles land. A policy of no production controls coupled with a direct subsidy on exports would provide a signal that the United States is unwilling to balance world supply and demand for wheat by adjusting production.

If one assumes an export elasticity of 0.5, the farm price would average 14 cents per bushel higher and acreage harvested would average about 11 million acres higher than under a continuation of current programs (table 5). Wheat production would increase on average by about 200 million bushels, and the export subsidy of $1.50 per bushel would increase exports by nearly 283 million bushels despite the higher price for wheat. But, wheat farmers' gross income would average over $1.6 billion lower

Table 4—Effects of an export subsidy of $1 per bushel[1]

Item	Unit	Baseline	Export elasticities				
			−0.25	−0.50	−1.00	−2.00	−4.00
Acreage planted	Million acres	72.52	73.34	73.84	74.30	75.89	77.41
Acreage harvested	do.	65.27	66.00	66.46	66.88	68.32	69.71
Yield per acre	Bushels	41.00	40.84	40.75	40.67	40.38	40.10
Supply:	Million bushels						
Beginning stocks	do.	2,183.07	1,988.62	1,831.26	1,445.60	1,218.31	1,149.23
Production	do.	2,674.25	2,695.23	2,707.79	2,719.66	2,759.04	2,795.72
Imports	do.	3.00	3.00	3.00	3.00	3.00	3.00
Total	do.	4,860.32	4,686.86	4,542.05	4,168.26	3,980.35	3,947.94
Use:							
Food and industry	do.	678.99	677.72	676.72	676.00	673.12	670.41
Seed	do.	91.21	92.20	92.82	93.39	95.34	97.22
Feed	do.	254.80	243.77	235.17	228.97	204.06	180.67
Exports	do.	1,382.14	1,475.17	1,551.70	1,697.51	1,821.20	1,900.87
Total	do.	2,407.15	2,488.86	2,556.41	2,695.88	2,793.72	2,849.17
Ending stocks	do.	2,453.18	2,197.99	1,985.64	1,472.39	1,186.64	1,098.77
Price	Dollars per bushel	3.33	3.43	3.51	3.57	3.80	4.02
Income indicators:	Million dollars						
Value of production	do.	8,909.74	9,254.52	9,512.55	9,711.22	10,489.61	11,234.00
Deficiency payments	do.	1,920.07	1,699.96	1,535.36	1,404.65	937.32	557.48
Storage payments	do.	152.41	141.63	135.59	127.43	105.52	82.77
Diversion payments	do.	789.26	757.31	737.72	719.42	656.87	596.39
Total gross income	do.	11,771.47	11,853.42	11,921.01	11,962.72	12,189.17	12,470.63
Variable expenses	do.	4,485.36	4,536.08	4,567.00	4,595.46	4,693.80	4,787.81
Total net income	do.	7,286.11	7,317.34	7,354.01	7,367.27	7,495.37	7,682.82
Net CCC outlays:[2]							
Deficiency payments	do.	1,770.90	1,558.87	1,423.08	1,289.15	871.61	518.19
Diversion payments	do.	791.69	759.51	736.60	718.42	652.11	586.85
Storage payments	do.	150.33	139.86	133.83	125.94	104.89	82.87
Net lending	do.	931.41	712.46	519.61	65.74	−134.37	−217.50
Export subsidy	do.	0	1,471.33	1,549.07	1,692.17	1,819.39	1,901.85
Other	do.	558.37	494.95	434.48	265.34	190.49	190.49
Total	do.	4,202.69	5,136.78	4,796.69	4,156.76	3,504.12	3,063.75
Consumer expenditures[3]	do.	37,783.45	37,847.03	37,897.74	37,935.77	38,080.31	38,217.50

[1]Unless indicated otherwise, numbers are crop year 1985/86 to 1991/92 averages.
[2]Fiscal year 1986-91 averages.
[3]For bakery products.

Table 5—Effects of no production control programs and an export subsidy of $1.50 per bushel[1]

Item	Unit	Baseline	Export elasticities				
			−0.25	−0.50	−1.00	−2.00	−4.00
Acreage planted	Million acres	72.52	84.14	84.77	85.38	87.35	88.88
Acreage harvested	do.	65.27	75.81	76.39	76.94	78.73	80.12
Yield per acre	Bushels	41.00	37.70	37.67	37.64	37.55	37.48
Supply:	Million bushels						
Beginning stocks	do.	2,183.07	2,222.74	1,939.34	1,325.02	1,148.59	1,000.12
Production	do.	2,674.25	2,856.97	2,876.49	2,895.59	2,956.29	3,003.28
Imports	do.	3.00	3.00	3.00	3.00	3.00	3.00
Total	do.	4,860.32	5,082.70	4,818.82	4,223.61	4,107.88	4,006.40
Use:							
Food and industry	do.	678.99	678.95	677.29	675.65	670.33	666.21
Seed	do.	91.21	105.49	106.27	107.02	109.44	111.32
Feed	do.	254.80	254.42	240.06	225.97	179.95	144.35
Exports	do.	1,382.14	1,537.30	1,664.83	1,893.33	2,050.69	2,172.59
Total	do.	2,407.15	2,576.16	2,688.45	2,901.98	3,010.61	3,094.48
Ending stocks	do.	2,453.18	2,506.55	2,130.38	1,321.63	1,097.27	911.82
Price	Dollars per bushel	3.33	3.33	3.47	3.60	4.02	4.35
Income indicators:	Million dollars						
Value of production	do.	8,909.74	9,528.81	9,975.60	10,421.99	11,899.56	13,078.15
Deficiency payments	do.	1,920.07	0	0	0	0	0
Storage payments	do.	152.41	152.03	138.90	125.37	82.53	52.53
Diversion payments	do.	789.26	0	0	0	0	0
Total gross income	do.	11,771.47	9,680.84	10,114.50	10,547.36	11,982.08	13,130.68
Variable expenses	do.	4,485.36	5,204.06	5,243.02	5,280.75	5,402.60	5,497.23
Total net income	do.	7,286.11	4,476.78	4,871.48	5,266.61	6,579.48	7,633.45
Net CCC outlays:[2]							
Deficiency payments	do.	1,770.90	0	0	0	0	0
Diversion payments	do.	791.69	0	0	0	0	0
Storage payments	do.	150.33	149.99	137.08	124.31	82.74	51.88
Net lending	do.	931.41	977.10	641.40	−40.28	−220.65	−374.96
Export subsidy	do.	0	2,300.90	2,491.79	2,833.05	3,075.14	3,266.52
Other	do.	558.37	579.41	478.76	211.45	190.49	167.12
Total	do.	4,202.69	4,007.40	3,749.03	3,128.50	3,127.73	3,111.56
Consumer expenditures[3]	do.	37,783.45	37,783.32	37,872.61	37,954.75	38,217.14	38,420.43

[1]Unless indicated otherwise, numbers are crop year 1985/86 to 1991/92 averages.
[2]Fiscal year 1986-91 averages.
[3]For bakery products.

than under the baseline as higher prices and increased production would fail to offset the loss in income from eliminating deficiency and diversion payments. Farmers' net income would fall by over $2.4 billion per year as production costs would rise because of expanded acreage. CCC net outlays would decline far less ($454 million) than would farmers' income, and consumer expenditures would average about $89 million higher.

Farmers' net income would fail to average above the level under current programs unless the export elasticity were to exceed 3.5. Farmers' gross income less variable costs would average 9.7 percent below its baseline value if the export elasticity were 2 and would exceed its baseline value by 4.8 percent if the export elasticity were 4.

Eliminating deficiency and diversion payments would reduce CCC net outlays even though exports are subsidized at $1.50 per bushel. CCC net outlays would average about $200 million to nearly $1.1 billion lower, but would fail to average less than $3 billion per year even if the export elasticity were 4.

Compared with the baseline, consumer expenditures would increase even though production controls would be eliminated because the export subsidy of $1.50 per bushel would increase the price of wheat domestically. Consumer expenditures would average $637 million higher if the export elasticity were 4. Total support costs including the change in consumer expenditures would decline by $454 million if the export elasticity were 4 and by $195 million if the export elasticity were 0.25.

$7/$2.50 Two-Price Program

Under this two-price program, wheat for domestic food and industrial use would be supported at $7 per bushel, whereas wheat for export, feed, and other nonfood uses would be supported at $2.50 per bushel. Wheat for food and industrial use would be supported through direct payments to producers and financed by a tax on wheat processors. Wheat processors would pass the cost of the tax on to consumers through higher prices for processed wheat products. We also assumed that all production control programs would be eliminated and that producer production response would be determined by the level of farm prices and would, therefore, be independent of the support level for wheat for food and industrial use.

The lack of production controls combined with lower food and industrial use, resulting from the $7-per-bushel support price, would cause the average farm price to fall below its baseline value. Food and industrial use would average about 45 million bushels lower, and wheat production would average 74-144 million bushels higher compared with a continuation of current farm programs (table 6). The farm price of wheat would fall by 25-73 cents per bushel depending on the magnitude of the export elasticity. Compared with their respective baseline values, exports would average 76-422 million bushels higher and ending stocks would average 133-1,011 million bushels lower.

The simulation results indicate farmers' net income would fall despite the $7-per-bushel support price on wheat for food and industrial use. Support payments to producers tend to greatly offset the effects of eliminating deficiency and diversion payments, but lower prices and expanded acreage cause farmers' net income to decline below its baseline value unless the export elasticity is substantially above 4. If the export elasticity were 0.5, farmers' net income would fall below its baseline value by over $2 billion per year and, if the export elasticity were 1, income would average over $1.9 billion per year lower.

CCC net outlays would decline dramatically under this program option. With the elimination of CCC-financed deficiency payments and no diversion payments, CCC outlays would be limited to loan activity, reserve storage payments, and costs of storing and handling CCC-owned wheat. CCC net outlays would average from $1.2 billion to less than $300 million per year or about $3 billion to nearly $4 billion lower than under a continuation of current farm programs.

The costs of supporting farmers' income is reflected in higher consumer expenditures for wheat products. Compared with the baseline, consumer expenditures for bakery products would average nearly $2.2

Table 6—Effects of a $7/$2.50 two-price program[1]

Item	Unit	Baseline	Export elasticities				
			−0.25	−0.50	−1.00	−2.00	−4.00
Acreage planted	Million acres	72.52	80.66	80.91	81.30	82.08	82.90
Acreage harvested	do.	65.27	72.66	72.88	73.23	73.94	74.69
Yield per acre	Bushels	41.00	37.86	37.85	37.83	37.80	37.76
Supply:	Million bushels						
Beginning stocks	do.	2,183.07	2,095.39	1,954.74	1,737.91	1,516.07	1,444.86
Production	do.	2,674.25	2,748.48	2,755.92	2,768.02	2,792.51	2,818.37
Imports	do.	3.00	3.00	3.00	3.00	3.00	3.00
Total	do.	4,860.32	4,846.87	4,713.71	4,508.93	4,311.58	4,266.22
Use:							
Food and industry	do.	678.99	633.13	633.13	633.13	633.13	633.13
Seed	do.	91.21	101.22	101.52	102.00	102.95	103.97
Feed	do.	254.80	334.13	328.07	320.38	310.47	282.36
Exports	do.	1,382.14	1,458.23	1,522.69	1,633.94	1,740.08	1,804.29
Total	do.	2,407.15	2,526.70	2,585.40	2,689.44	2,277.63	2,823.75
Ending stocks	do.	2,453.18	2,320.17	2,128.31	1,819.50	1,533.95	1,442.48
Price	Dollars per bushel	3.33	2.60	2.65	2.72	2.90	3.08
Income indicators:	Million dollars						
Value of production	do.	8,909.74	7,137.36	7,311.74	7,539.17	8,096.20	8,669.70
Deficiency payments	do.	1,920.07	2,787.44	2,752.14	2,707.76	2,596.38	2,484.24
Storage payments	do.	152.41	141.00	136.40	128.09	106.80	80.88
Diversion payments	do.	789.26	0	0	0	0	0
Total gross income	do.	11,771.47	10,065.80	10,200.80	10,375.03	10,799.38	11,234.82
Variable expenses	do.	4,485.36	4,988.82	5,004.28	5,028.41	5,076.65	5,121.18
Total net income	do.	7,286.11	5,076.98	5,196.00	5,346.62	5,722.73	6,113.64
Net CCC outlays:[2]							
Deficiency payments	do.	1,770.90	0	0	0	0	0
Diversion payments	do.	791.69	0	0	0	0	0
Storage payments	do.	150.33	139.00	134.77	126.51	106.53	81.24
Net lending	do.	931.41	529.06	394.38	151.79	−54.65	−127.36
Export subsidy	do.	0	0	0	0	0	0
Other	do.	558.37	499.09	446.03	357.03	280.21	280.22
Total	do.	4,202.69	1,167.15	975.17	635.34	332.11	234.10
Consumer expenditures[3]	do.	37,783.45	39,954.32	39,954.32	39,954.32	39,954.32	39,954.32

[1]Unless indicated otherwise, numbers are crop year 1985/86 to 1991/92 averages.
[2]Fiscal year 1986-91 averages.
[3]For bakery products.

billion per year higher. Over the entire range of export elasticities, the cost of supporting farmers' income by consumers and taxpayers would average about $850 million to $1.8 billion per year lower than under current programs. Farmers' net income would average about $2.2 billion to $1.2 billion lower over the range of export elasticities.

$10/$2.50 Two-Price Program

Under the $7/$2.50 two-price program, farmers' income would decline below that predicted under a continuation of current farm programs unless the export elasticity were above 4. Supporting wheat for food and industrial use at $10 rather than at $7 per bushel would depress farm prices even more because of lower food and industrial use. But, the negative effect on gross income would be offset by larger direct payments.

Wheat production and use would vary only marginally from their respective values under the $7/$2.50 two-price program. The farm price of wheat would average 2-3 cents per bushel lower compared with the previous program, and gross farm income would average $1.5-1.6 billion per year higher (table 7). Compared with the baseline, the $10/$2.50 two-price program would increase gross farm income if the export elasticity were above about 0.5. Farmers' net income would average from about $650 million lower to about $420 million higher per year than under a continuation of current programs. Farmers' net income would average about $512 million lower per year if the export elasticity were 0.5. CCC net outlays would decline to about $1.1 billion per year. Thus, CCC net outlays would average over $3.1 billion per year lower than under a continuation of current programs.

The costs of supporting farmers' income would be shifted from taxpayers to consumers. Compared with the baseline, consumer expenditures for bakery products would average about $3.7 billion per year higher, which more than offsets the decline in CCC net outlays if the export elasticity fails to exceed 1.50. If the export elasticity were 0.5, the total cost (taxpayer plus consumer) of supporting farm income exceeds its baseline value by about $568 million per year.

Comparing tables 6 and 7 reveals that if the export elasticity were below 1.1 and if the support price on wheat for food and industrial use were increased, the total (consumer plus taxpayer) cost of supporting farmers' income would rise faster than farmers' net income. If the export elasticity were above 1.1, the increase in farmers' net income would exceed the increase in total support costs. Even if the export elasticity were 4, farmers' net income would increase by only $1.04 for each $1 increase in consumer expenditures.

Conclusions

Because the export wheat market is generally more responsive to changes in price than the domestic wheat market, economic theory suggests that we could increase farmers' revenues by segmenting the two markets (domestic and international) and by setting a high support price on wheat for domestic use and a lower support price on wheat for export. Stated differently, economic theory suggests we could increase farmers' revenues if we subsidize wheat exports and tax wheat for domestic use. Of course, if farmers' revenues are increased through the marketplace, the public costs of supporting farmers' incomes would probably fall. From a budgetary viewpoint, such a program is particularly appealing because both farmers and taxpayers might be better off.

The simulation results indicate that a federally funded export sudsidy of 50 cents to $1 per bushel combined with current production control programs would strengthen farm prices and would increase farmers' incomes. Deficiency and diversion payments would decline, but total Government program outlays would increase unless the export elasticity is nearly 1 or higher. Higher farm prices also translate into higher consumer expenditures for wheat products. And, if we calculate the total costs of supporting farmers' incomes as the sum of the change in consumer expenditures and taxpayer costs, the export elasticity must be greater than 1 before the costs of supporting farmers' incomes would decline. The results indicate that, compared with a continuation of current programs and assuming an export elasticity of 1 for U.S. wheat, a 50-cent per bushel subsidy would increase farmers'

Table 7—Effects of a $10/$2.50 two-price program[1]

Item	Unit	Baseline	Export elasticities				
			−0.25	−0.50	−1.00	−2.00	−4.00
Acreage planted	Million acres	72.52	80.48	80.80	81.18	81.93	82.81
Acreage harvested	do.	65.27	72.49	72.78	73.12	73.80	74.61
Yield per acre	Bushels	41.00	37.87	37.86	37.84	37.80	37.76
Supply:	Million bushels						
Beginning stocks	do.	2,183.07	2,175.30	2,030.03	1,795.30	1,527.85	1,415.87
Production	do.	2,674.25	2,742.56	2,752.70	2,764.27	2,787.88	2,815.64
Imports	do.	3.00	3.00	3.00	3.00	3.00	3.00
Total	do.	4,860.32	4,920.86	4,785.73	4,562.58	4,318.73	4,270.51
Use:							
Food and industry	do.	678.99	595.63	595.63	595.63	595.63	595.63
Seed	do.	91.21	100.99	101.39	101.85	102.77	103.86
Feed	do.	254.80	337.46	320.29	322.75	304.88	284.37
Exports	do.	1,382.14	1,461.43	1,526.93	1,643.00	1,766.31	1,835.16
Total	do.	2,407.15	2,495.50	2,554.25	2,663.22	2,769.60	2,819.02
Ending stocks	do.	2,453.18	2,425.36	2,231.50	1,899.35	1,549.14	1,451.49
Price	Dollars per bushel	3.33	2.57	2.63	2.70	2.87	3.06
Income indicators:	Million dollars						
Value of production	do.	8,909.74	7,038.03	7,246.16	7,468.72	7,994.76	8,609.00
Deficiency payments	do.	1,920.07	4,427.42	4,388.10	4,347.20	4,248.29	4,135.04
Storage payments	do.	152.41	146.76	137.45	130.37	110.99	83.38
Diversion payments	do.	789.26	0	0	0	0	0
Total gross income	do.	11,771.47	11,612.21	11,771.71	11,946.29	12,354.05	12,827.42
Variable expenses	do.	4,485.36	4,977.68	4,997.48	5,020.98	5,067.37	5,121.80
Total net income	do.	7,286.11	6,634.52	6,774.23	6,925.31	7,286.68	7,705.62
Net CCC outlays:[2]							
Deficiency payments	do.	1,770.90	0	0	0	0	0
Diversion payments	do.	791.69	0	0	0	0	0
Storage payments	do.	150.33	145.00	135.65	128.76	110.60	83.67
Net lending	do.	931.41	597.89	462.65	211.79	−42.76	−120.29
Export subsidy	do.	0	0	0	0	0	0
Other	do.	558.37	526.71	476.62	380.60	280.22	280.22
Total	do.	4,202.69	1,269.60	1,074.93	721.16	348.06	243.60
Consumer expenditures[3]	do.	37,783.45	41,478.71	41,478.71	41,478.41	41,478.71	41,478.41

[1]Unless indicated otherwise, numbers are crop year 1985/86 to 1991/92 averages.
[2]Fiscal year 1986-91 averages.
[3]For bakery products.

net incomes by about $65 million per year (less than 1 percent) while lowering CCC net outlays by $37 million per year (less than 1 percent) and raising consumer expenditures by $108 million (less than 1 percent) per year. A $1-per-bushel subsidy (again assuming an export elasticity of 1) would increase farmers' net incomes by about $81 million while lowering CCC net outlays by $46 million and raising consumer expenditures by $152 million. Thus, subsidizing exports by as much as $1 per bushel will only moderately increase wheat farmers' net income.

Relaxing production controls while simultaneously subsidizing exports by $1.50 per bushel would reduce CCC net outlays by $195 million to $1.1 billion per year for FY 1986/87 to 1991/92. Despite the export subsidy, farmers' net income would fall unless the export elasticity were above about 3.5. Assuming an export elasticity of 1 and no production controls, a $1.50-per-bushel sudsidy would reduce farmers' net income by over $2 billion per year, CCC net outlays would fall by about $1.1 billion, and consumer expenditures would increase by $171 million per year compared with a continuation of current programs.

Establishing a high support price for wheat for food and industrial use and a low support price for wheat for export and other domestic uses may not benefit wheat producers. If production controls are eliminated, setting the support price for food and industrial use at $7 per bushel and the support price for export and other domestic uses at $2.50 per bushel could substantially reduce farmers' net income. For example, if the export elasticity were 1, net farm income would average $1.9 billion per year lower, CCC net outlays would average $3.6 billion per year lower, whereas consumer expenditures would average nearly $2.2 billion per year higher compared with a continuation of current programs.

Finally, a $10/$2.50 two-price program would increase farmers' net income if the export elasticity is greater than 2. CCC net outlays would decline by about $3-4 billion per year compared with a continuation of current programs. However, consumer expenditures would increase by about $3.7 billion per year.

Past studies generally suggest the elasticity of U.S. wheat exports is less than 2. Thus, subsidizing U.S. wheat exports will probably increase wheat producers' incomes only moderately, especially if the cost of supporting farmers' incomes by taxpayers and consumers is not permitted to increase significantly. Put more simply, export subsidy programs cannot provide large positive benefits to producers while simultaneously lowering the direct and consumer costs of supporting farmers' incomes. In addition, a policy of across-the-board export subsidies would probably cause the United States to lose some of its ability to influence other countries to reduce and eliminate protectionist policies. Competitor countries could, of course, retaliate by further expanding their subsidy programs or by reducing imports of U.S. agricultural and nonagricultural commodities. Export subsidy programs should not necessarily be shelved altogether. Targeted export subsidies may indeed provide positive benefits to producers as well as lower consumer and taxpayer costs of supporting farmers' incomes if targeted at countries with import demand elasticities above 2. Export subsidies may be necessary to maintain the U.S. share of the world wheat market and to force major competitors to rethink their export policies.

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Measuring Implicit Rental Rates for Farm Capital

By James Hrubovcak*

Abstract

Developing implicit rental rates for capital inputs is an important step in understanding the impact of tax law changes on agricultural investments. This article develops a methodology for estimating implicit rental rates and presents annual estimates of rental rates for seven categories of farm equipment and structures from 1955 to 1979. This article also compares these rental rates with those estimated under a no-tax alternative. The author developed a method for estimating marginal Federal income tax rates for farm sole proprietorships.

Keywords

Implicit rental rate, marginal tax rate, investment, depreciation, capital

Introduction

Federal income tax regulations are important determinants of which assets make up the capital stock. However, taxes only affect the mix of the capital stock if the effects of tax laws are not neutral toward all assets—that is, if they distort the relative after-tax prices of assets. In the absence of other distortions, if tax provisions such as accelerated methods of depreciation, short tax lives, and the investment tax credit lower the after-tax price of some assets more than others, investors are encouraged to purchase more of the affected assets (*5*).[1] Any resulting change in the capital stock may lower economic efficiency as investors are responding to tax factors rather than market factors.

One way to analyze the effects of changes in tax laws on the mix of capital inputs is to compare implicit rental rates for various assets. Rental rates differ from asset prices in that they measure the cost of a flow of a capital service during a specific period. Rental rates are a function of the prices of assets, rates of economic or capacity depreciation, tax variables, the discount rate, and the rate of inflation. Rental rates are the cost of capital services that are internally supplied by the firm (*5*). Therefore, as tax variables are changed, so is the cost of supplying capital services and the demand for those services.

This article presents annual estimates of the marginal income tax rates of farm sole proprietorships and rental rates for seven categories of farm equipment and structures from 1955 to 1979 in an attempt to improve the current understanding of how Federal income tax policy affects the level of agricultural investment.

Estimating Implicit Rental Rates

The implicit rental price of a unit of capital service is the after-tax cost of the capital service that is internally supplied by the firm. When the firm is treated as a lessor of capital services, the rental rate is the price the firm will charge for each unit of capital services leased. Therefore, the implicit rental rate is the rate the firm must charge to earn a required after-tax rate of return. The rental rate is a function of the price of the asset, the rate of capacity depreciation, the tax variables, the discount rate, and the rate of inflation. True rental rates are directly observed from market transactions with active rental markets. Implicit rental rates are

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[1]Italicized numbers in parentheses refer to items in the References at the end of this article.

estimates of the true rental rates that would prevail under given sets of assumptions. Nonneutral tax-induced changes in rental rates affect the capital stock as lower taxed capital inputs are substituted for higher taxed capital inputs. Assuming perfectly competitive market conditions and cost-minimizing behavior, firms adjust their stocks of capital inputs until the ratio of the marginal products of any pair of inputs equals the ratio of their respective rental rates. To the degree that inputs are substitutable, a change in tax law which decreases the rental rate of one input relative to other inputs will increase the demand for the lower priced input until the cost-minimization conditions are satisfied. This situation does not imply that the same tax treatment is appropriate for each type of asset. In the presence of an otherwise neutral income tax system, inflation can bias the mix of inputs used. Because tax depreciation deductions are based on the historical cost of assets, inflation reduces the real value of the nominal deductions, with the reduction being the greatest for shorter lived assets (*8*). During inflation, the use of historical cost tax depreciation for all assets increases demand for long-lived assets relative to assets with shorter lives.

A formula for implicit rental rates can be developed from the equality between the purchase price of an asset and the present value of the future rents generated by the asset (*9*). Assuming constant new asset price expectations and allowing for alternative depreciation patterns, the basic Jorgenson equation converted to discrete time is:

$$q_i = \sum_{t=1}^{L_i} u_i a_i(t)/(1 + r)^t \qquad i = 1,2,\ldots,m \qquad (1)$$

where q_i is the purchase price of the ith asset when new, L_i is the service life of the asset, u_i is the rental rate for a new (undepreciated) unit of capital, $a_i(t)$ is the capacity of a unit of capital in year t of its service life, and r is the discount rate. The capacity of the asset is 1 in period 1 and declines over its service life as a function of the rate of capacity depreciation.

Equation (1) ignores all tax considerations. When capital income is subject to an income tax, the term on the right side of equation (1) must be modified and expanded to include the effects of the tax. The expanded term included expressions for the present value of the after-tax rents generated by the asset and for the present value of the tax savings produced by the investment tax credit and tax depreciation deductions. Assuming the firm's marginal tax rate remains constant as T, equation (1) respecified to accommodate the tax system becomes:

$$q_i = (1 - T)u_i A_i + C_i q_i + T(1 - dc_i)B_i q_i \qquad (2)$$
$$i = 1,2,\ldots,m$$

where $(1 - T)u_i A_i$ is the present value of the after-tax rents, $C_i q_i$ is the present value of the tax saving produced by the investment tax credit, and $T(1 - dc_i)B_i q_i$ is the present value of the tax saving produced by tax depreciation deductions.

With constant price expectations and a constant marginal tax rate, the rental rate remains constant over the life of the asset. The capacity of the asset, however, declines over the life of the asset so that:

$$A_i = \sum_{t=1}^{L_i} a_i(t)/(1 + r)^t \qquad i = 1,2,\ldots,m \qquad (3)$$

where r is the discount rate which is the real after-tax rate of return required by the firm.

Although the firm pays taxes on the rents generated by each asset, the firm is also allowed to deduct the decline in the value of the asset as an expense. If the present value of the depreciation deductions claimed for tax purposes is equal to the true decline in market value for each asset, the tax system does not bias investment toward any asset.

If $b_i(t)$ is the fraction of the price of the ith asset that is deducted from taxable income in year t of the asset's tax life (M_i), the present value of the tax depreciation is $TB_i q_i$, where:

$$B_i = \sum_{t=1}^{M_i} b_i(t)/(1 + r)^t(1 + p)^t \quad i = 1,2,\ldots,m \quad (4)$$

and p is the rate of inflation. However, in some years the tax depreciation base was reduced by the amount of the investment tax credit. Therefore, a more general expression for the present value of tax depreciation deductions is $T(1 - dc_i)B_i q_i$, where d is the percentage of the credit, if any, which must be

used to reduce the tax depreciation base. In addition to the depreciation deductions, firms may also be eligible to claim an investment tax credit (c). If firms claim the credit at the end of the first year of the asset's service life, the present value of the credit is $C_i q_i$, where:

$$C_i = c_i/(1 + r)^1(1 + p)^1 \qquad i = 1,2,...,m \qquad (5)$$

Given the market price of the asset, equation (2) can be rewritten as:

$$u_i = q_i[1 - C_i - T(1 - dc_i)B_i]/A_i(1 - T) \qquad (6)$$

$$i = 1,2,...,m$$

to solve for the implicit rental rate (u_i) that the firm must charge to earn the required real after-tax rate of return (r).[2] Equation (6) can also show how changes in tax laws may affect the rental rate. For example, an increase in the real value of the investment tax credit, through a change in tax laws or a reduction in the inflation rate, will decrease the rental rate. This decreased rental rate is observable by differentiating equation (6) with respect to the present value of the investment tax credit:[3]

$$\partial u_i/\partial C_i = -q_i/A_i(1 - T) < 0 \qquad i = 1,2,...,m \qquad (7)$$

Because $q_i > 0$, $A_i > 0$, and $0 < T < 1$, the derivative $\partial u_i/\partial C_i < 0$.

Similarly, equation (8) shows that an increase in the present value of the tax depreciation deductions also reduces the rental rate.

$$\partial u_i/\partial B_i = -q_i T/A_i(1 - T) < 0 \qquad i = 1,2,...,m \qquad (8)$$

A change in the marginal income tax rate with respect to the rental rate, however, results in ambiguous effects:

$$\partial u_i/\partial T = q_i(1 - C_i - B_i)/A_i(1 - T)^2 \qquad (9)$$

$$i = 1,2,...,m$$

For example, a tax rate reduction reduces the tax on the rents generated by the asset and also reduces the value of the tax depreciation deductions. In most cases, decreasing the tax rate will lower the rental rate. However, equation (9) shows that decreasing the marginal income tax rate (T) increases the rental rate, provided $C_i + B_i > 1$. In other words, a decrease in the tax rate will cause rental rates to rise if the purchase price of the asset is less than the present value of the investment tax credit plus the present value of tax depreciation deductions. If the purchase price is less than the present value of the credit and the depreciation deductions, the Government returns more than a dollar to the firm in tax saving for every dollar of investment.

Data

As stated earlier, implicit rental rates are estimates of true rental rates that would exist under a given set of assumptions. Therefore, it is important that I discuss the rationale for these assumptions, especially those regarding the economics characteristics of the assets, the tax parameters, and the discount rate.

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[2]The rental rate in equation (6) assumes the asset is completely depreciated and, therefore, could not be sold at the end of its service life. However, equation (6) could be generalized to consider any salvage value and the tax consequences of a sale.

When an asset is sold for an amount less than or equal to the original purchase price, the proceeds from the sale must be recaptured as ordinary income, with the present value of the proceeds (P) equal to:

$$P = [1 - T]\,[q(1 + g)^L/(1 + r)^L(1 + p)^L]$$

where g is the nominal growth rate in used asset prices.

When an asset is sold for an amount greater than the original purchase price, that portion of the proceeds equal to the original purchase price must still be recaptured as ordinary income, and only the amount in excess of the purchase price is considered a capital gain for tax purposes. The present value of the capital gain (G) can be represented as:

$$G = [(q(1 + g)^L - q)/(1 + r)^L(1 + p)^L] - T(1 - j)[(q(1 + g)^L - q)/(1 + r)^L(1 + p)^L]$$

where the first part of the equation is the capital gain portion of the sale and the second part of the equation is the tax on the capital gain with j being the capital gains exclusion.

Including both the ordinary income generated by the sale and the capital gain, if any, equation (6) can be recast as:

$$u = [q[1 - C - T(1 - dc)B]/A(1 - T)] - P - G$$

[3]For simplicity, I assumed that the investment tax credit did not affect the basis for depreciation purposes.

Economic Characteristics of Assets

I estimated rental rates for autos, trucks, tractors, long-lived farm equipment, crop storage structures, multipurpose structures, and unitary livestock facilities. Asset price indexes for each of the four farm machinery categories were set equal to the respective Bureau of Labor Statistics (BLS) price index for passenger cars, trucks, wheel-type farm tractors, and agricultural machinery excluding farm tractors (*20*). A single price index series for all three structure categories was taken from the Bureau of Economic Analysis (BEA) capital stock study (*19*).

The service lives for each equipment category are based on averages of Bulletin F depreciation lives and are taken from Ball (*1*). The service lives for autos, trucks, tractors, and other long-lived equipment are 12, 11, 9, and 20 years, respectively.[4] Unitary livestock facilities and multipurpose agricultural structures had service lives of 50 years, whereas the service life of crop storage structures was 25 years.

The rate of economic depreciation for each category is approximated by the double-declining balance depreciation method where the capacity of the ith asset in year t of the asset's service life (L_i) is represented as:

$$a_i(t) = [1 - (2/L_i)]^{t-1} \qquad i = 1,2,...,m \qquad (10)$$

for $1 \leq t \leq L_i$, and $a_i(t) = 0$ for $t > L_i$. To test the sensitivity of the capacity depreciation assumption, I also estimated rental rates assuming a "one-hoss shay" depreciation pattern (see appendix) where the capacity of the ith asset in year t is represented as:

$$a_i(t) = 1 \qquad i = 1,2,...,m \qquad (11)$$

for $1 \leq t \leq L_i$, and $a_i(t) = 0$ for $t > L_i$. These rental rates are presented in the appendix of this article.

Tax Lives, Investment Tax Credit, and Tax Depreciation Methods

The tax lives selected by farmers are based on the allowable lives which result in the greatest tax saving over the service life of the asset. Greatly affecting the tax life, however, was the eligibility of the asset for the investment tax credit. From 1962 to 1968 and again from 1971 to 1974, eligible assets (each machinery category and crop storage structures) with a useful life of at least 8 years received the full 7-percent investment tax credit.[5] Eligible assets with a tax life of 6 or 7 years received two-thirds of the 7-percent credit. From 1975 to 1979, the investment tax credit was increased to 10 percent, and the tax life requirement for each level of the credit was reduced by 1 year. The tax savings associated with the investment tax credit was enough to offset the savings from selecting shorter tax lives. As a result, I assumed that farmers selected the minimum allowable tax life which qualified for the entire investment tax credit. Table 1 presents the tax lives for each category.

Table 1—Tax lives for each asset category

Asset category	Tax life				
	1955-61	1962-68	1969-70	1971-74	1975-79
	Years				
Autos	6	8	3	8	7
Trucks	6	8	4	8	7
Tractors	10	10	10	8	8
Long-lived farm equipment	15	10	10	8	8
Crop storage structures	25	10	10	8	8
Unitary livestock facilities	50	25	25	20	20
Multipurpose structures	50	25	25	20	20

The tax depreciation methods chosen were also based on the tax savings generated by each of the allowable methods.[6] From 1955 to 1969, assets in each category could have been depreciated under the

[4]Although the 9-year economic life of tractors is consistent with Bulletin F, some studies indicate that their economic life may be longer (*11*). Therefore, rental rates for farm tractors with a 12-year economic life have also been estimated.

[5]Unitary livestock facilities became eligible for the credit in 1971.

[6]Although not all farmers select a single depreciation pattern, data do not allow us to determine which methods are employed and to what extent each method is used. To be consistent, I chose the option which resulted in the lowest rental rate.

sum-of-year's-digits method or the double-declining balance method. Under both alternatives, a portion of an asset could be depreciated at the straight line rate if the switch resulted in larger depreciation deductions. The sum-of-year's digits with a switch to the straight line rate resulted in the greatest tax savings and was the selected method for each category. From 1970 to 1979, each machinery category and crop storage structure were allowed the same accelerated depreciation methods allowed prior to 1970. However, unitary livestock structures and multipurpose structures were limited to a depreciation rate equal to 150 percent of the straight line rate.

Discount Rate

I also had to specify the discount rate used to calculate the present value of the rents, investment tax credit, and the tax depreciation deductions; the discount rate is the opportunity cost to the investor of purchasing the asset. As discussed by Eisner and Strotz (*3*), the appropriate interest rate used to represent the opportunity cost does not fall short of the investment horizon. The discount rate used for equipment and structures is, therefore, a weighted average of the longrun real after-tax interest rate (external financing) and the expected longrun real after-tax return to equity (internal financing). Nominal interest charges are deductible from taxable income, and inflation reduces the real value of nominal interest and principal payments on debt. When these two factors are considered, the real cost of external or debt financing (r_d) is:

$$r_d = [r_n(1 - T) - p]/(1 + p) \qquad (12)$$

when r_n is the nominal interest rate. After the real costs of both equity and debt financing are combined, the real cost of capital or real discount rate is:

$$r = fr_d + (1 - f)r_e \qquad (13)$$

where f is the fraction debt financed, r_d is the real after-tax cost of debt financing, and r_e is the real after-tax return to equity (*13*).

Data from the 1969 and 1979 Farm Finance Surveys (*17, 18*) indicate that the fraction of farm investment that is debt financed is about 50 percent. In keeping with Eisner and Strotz' theory that the appropriate interest rate should be a longrun rate, interest rates for external financing were rates charged by Federal Land Banks on new farm loans (*14, 16*). Following Coen (*2*) and Penson, Romain, and Hughes (*11*), I assumed the longrun real after-tax rate of return to equity was constant for each asset over the period studied. Although there are few data regarding the appropriate longrun real after-tax return to equity, Melichar found that the real total return to farm assets since 1950 has averaged about 8 percent (*10*). Gertel also found that the real before-tax return to cash rented farmland averaged 8.1 percent from 1940 to 1980 (*4*). Therefore, for this analysis I decided to use a real after-tax return to equity of 6 percent.[7]

One can also respecify the discount rate to account for State and local property taxes. If the property tax is correctly assessed, the property tax variable can be specified explicitly in the rental price equation or, because it increases the cost of capital, the variable can be specified in the discount rate (*7*). Accounting for the deductibility of property taxes from the Federal income tax and the fact that property taxes are generally levied in the current year but payable in the next year, I recast equation (13) as:

$$r = fr_d + (1 - f)r_e + [(1 - T)K/(1 + p)] \qquad (14)$$

where K is the property tax rate expressed as a percentage of the value of the asset.

Because many States exempt farm personal property from taxation, I assumed that property taxes were levied only on the three structure categories. Property tax rates were taken from U.S. Department of Agriculture (USDA) estimates of farm real estate taxes (*6*).

Marginal Income Tax Rates

Finally, I developed an average marginal Federal income tax rate for new farm investment. The marginal tax rate is the expected tax that an investor or firm would pay on an additional dollar of income prior to undertaking any new investment. This tax rate is used to determine the rental rates

[7]The appendix to this article shows rental rates for long-lived farm equipment under returns to equity of 3 percent and 9 percent.

for farm capital. It was necessary to create an average farm sole proprietorship Federal income tax return for the years data were available to estimate this marginal tax rate. Starting with adjusted gross income, I replaced the amount of depreciation and interest deductions claimed for new investment. After dividing by the number of businesses and subtracting the personal exemption, dependent credit, and, if applicable, the standard deduction or zero bracket amount, I estimated average taxable income.[8] One can estimate the average marginal income tax rate by comparing the average taxable income with the appropriate tax table.

Adjusted Gross Income. Adjusted gross income is gross income from all taxable sources reduced by adjustments such as the ordinary and necessary expenses of operating a trade or business. Therefore, adjusted gross income combines both onfarm and off-farm income less total depreciation, interest, and other allowable farm business expenses. Except for 1964 and 1965, the Internal Revenue Service (IRS) has published annual data on adjusted gross income for farm sole proprietorships from 1962 to 1979 (*22*). I used adjusted gross income rather than a narrower definition of income such as net income from farming because onfarm and off-farm income are interrelated. Off-farm income finances farm investment, and farm-related expenses offset off-farm income.

Tax Depreciation Deductions. Historically, IRS only publishes total depreciation deductions claimed in the current year, but it publishes neither data on farm investment nor allowances for depreciation deductions claimed on new investment. Therefore, to calculate the marginal tax rate, I had to develop a procedure for separating the amount of depreciation claimed on new investment in the current year from depreciation deductions carried forward from investment in prior years. Therefore, I depreciated investment data for trucks, tractors, other farm equipment, and structures published by USDA (*15*) over the selected tax lives. Because there are no data regarding the actual depreciation method selected by farmers, I assumed that farmers selected the depreciation method and tax life which resulted in the greatest amount of tax savings over the economic life of each asset.

Using investment data provided by USDA and the assumed tax life and depreciation method, I calculated the total farm depreciation pattern including the amount claimed on new investment in the current year. I applied the percentage of first-year depreciation to IRS-published data on total depreciation deductions to estimate the IRS depreciation deductions claimed on new investment. Except for 1968 and 1969 (during which the stimulus of the investment tax credit was only partially in effect), the percentage of tax depreciation deductions claimed for new investment in the first year increased steadily through time (table 2). Much of this increase results from increases in the nominal amount of investment rather than from changes in tax laws. For example, gross farm capital expenditures, excluding farm households, increased from \$4.5 billion in 1962 to \$6.8 billion in 1967; it then fell to \$6.1 and \$6.2 billion in 1968 and 1969, respectively.

Although the level of investment appears to be the most significant determinant of first-year depreciation, certain tax law changes have also had an impact. In 1958, the introduction of the additional first-year depreciation option allowed an additional deduction of 20 percent of eligible investment. Revenue Procedure 62-21, enacted in 1962, significantly shortened the existing Bulletin F tax lives for many assets (*23*). In 1971, the Asset Depreciation Range (ADR) System allowed taxpayers to further reduce tax lives by 20 percent (*21*). However, the impact of reducing tax lives may have been limited because choosing the shorter tax life may have decreased the investment tax credit or eliminated the additional first-year depreciation deduction.

Interest Paid Deduction. IRS publishes the total interest-paid deduction and does not separate interest expenses incurred for investment. Therefore, I assumed that all IRS interest expenses were attributable to investment. Furthermore, I calculated the percentage of interest charges on new debt using the data and methodology employed by USDA to estimate interest charges on farm real estate

[8]Because Schedule Y, the tax table used for this analysis, incorporates the standard deduction, there is no need to explicitly consider the standard deduction.

Table 2—Gross farm investment, percentage of total tax depreciation deductions from new investment, total IRS tax depreciation, and IRS tax depreciation from new investment, 1962-79

Year	Gross farm investment	Total tax depreciation resulting from new investment	Total IRS tax depreciation deduction, sole proprietorships	IRS depreciation resulting from new investment
	Million dollars	*Percent*	*Million dollars*	
1962	4,473	27	3,177	858
1963	4,846	30	3,175	953
1964	5,101	32	3,253	1,041
1965	5,566	33	3,443	1,136
1966	5,095	35	3,693	1,292
1967	6,836	36	3,915	1,410
1968	6,112	32	4,126	1,320
1969	6,214	31	4,439	1,376
1970	6,793	32	4,598	1,471
1971	6,789	34	4,824	1,640
1972	7,480	36	5,290	1,905
1973	10,172	42	6,473	2,719
1974	11,444	42	7,189	3,019
1975	12,384	41	7,857	3,221
1976	13,968	42	8,845	3,715
1977	15,015	41	8,758	3,591
1978	17,948	43	10,208	4,389
1979	19,874	44	11,241	4,946

debt.[9] I then applied that percentage to the IRS data on the interest-paid deduction to estimate the interest expenses resulting from new investment.

Because the procedure used by USDA to estimate interest charges on real estate debt has already been explained in detail (*12*), only an overview will be presented here. Loan and contractual interest rate data are from Federal land banks, life insurance companies, Farmers Home Administration, commercial banks, and individuals and others. Loans outstanding at the beginning of each year and new loans made during the year are from primary sources (Farm Credit Administration, American Council of Life Insurance Companies, the Farmers Home Administration, and the Federal Deposit Insurance Corporation), except for loans from individuals and others which are benchmarked on Census of Agriculture data. Data on interest rates are more tenuous in that the average interest rates on loans outstanding are all estimates, except for Federal land banks and the Farmers Home Administration. Interest rates on new loans are based on surveys conducted by USDA and the Farm Credit Administration.

I estimated total interest charges for each year by multiplying the average loans outstanding during the year for each year for each lender by the appropriate average interest rate on loans outstanding. Multiplying the average interest rate on new loans by lender by the amount of new loans made during the year yields an estimate of interest charges resulting from new investment. I then multiplied the percentage of total interest charges representing new investment by the IRS data on interest expenses to estimate the amount of interest expenses from debt incurred on new investment.

[9] I considered only the USDA real estate debt series to exclude the short-term production loans contained in the nonreal-estate debt category. The nonreal-estate debt category contains loans for recurring production items such as feed and seed. Because these loans are short term, the percentage of interest expenses on new loans relative to total interest expenses would be large and would inflate the percentage of total interest charges resulting from new investment.

Table 3—Percentage of interest charges from new investment, total IRS interest charges, and total IRS interest from new investment, 1962-79

Year	Total interest charges resulting from new investment	Total IRS interest deduction, sole proprietorships	IRS interest deductions resulting from new investment
	Percent	*Million dollars*	
1962	30	902	269.10
1963	32	997	316.42
1964	32	1,064	340.79
1965	32	1,160	365.54
1966	31	1,358	414.50
1967	27	1,507	407.47
1968	26	1,708	439.64
1969	26	1,834	479.81
1970	24	2,035	487.16
1971	27	2,207	588.06
1972	34	2,459	829.48
1973	41	2,915	1,194.75
1974	38	3,256	1,219.47
1975	33	3,865	1,289.09
1976	33	4,595	1,528.80
1977	36	4,777	1,730.05
1978	28	5,872	1,636.00
1979	30	7,243	2,173.00

Table 3 shows estimates of the percentage of the total interest charges which represents interest charges on new investment, the IRS estimate of total interest deductions, and the estimated amount of IRS interest deductions resulting from new investment.

Estimating Marginal Tax Rates. The final step in the estimation procedure was to sum adjusted gross income and the total tax depreciation and interest expenses resulting from new investment; I then divided that total by the number of farm business returns to estimate adjusted gross income per return. I then reduced per-return adjusted gross income by the personal exemption and dependent credit to estimate taxable income.[10] I then estimated the marginal tax rate by comparing taxable income with the appropriate tax table. Table 4 presents per-return adjusted gross income (including tax depreciation and interest expenses on new investment), taxable income, and marginal income tax rate from 1962 to 1979.[11]

The marginal tax rate declined from 20 percent in 1962 and 1963 to 17 percent in 1965; it then increased to a high of 25 percent in 1978 (table 4). However, the decline in marginal tax rate from 1963 to 1965 was caused by the Revenue Act of 1964 rather than by a drop in taxable income. The

[10]In addition to the personal exemption, I assumed that each return claimed three dependents. Since 1955, both the personal exemption and the dependent credit have been equal; they increased from $600 in 1955 to $625 in 1970, to $675 in 1971, to $750 in 1972, and to $1,000 in 1979.

[11]An example of the procedure for 1979 is as follows:

Farms total, returns with and without adjusted gross income

Adjusted gross income	$56,636,323,000
+Depreciation on 1979 investment ($11,241,468,000*0.44)	$4,946,245,920
+Interest on 1979 investment ($ 7,242,712,000*0.30)	$ 2,172,813,600
	$63,755,382,520
÷ Number of returns	2,921,934
	$21,820
−Personal exemption and three dependents	$4,000
Taxable income	$17,820

Table 4—Per return, adjusted gross income, taxable income, and marginal income tax rates, 1962-79

Year	Per return adjusted gross income	Per return taxable income	Per return marginal income tax rates
	Dollars		*Percent*
1962	4,853.33	1,968.00	20
1963	5,033.17	2,129.85	20
1964	5,907.53	2,916.78	20
1965	6,718.01	3,646.21	17
1966	7,028.83	3,935.39	17
1967	7,381.25	4,243.12	19
1968	8,128.65	4,915.78	19
1969	8,633.66	5,370.29	19
1970	8,869.38	5,482.44	19
1971	9,507.02	5,571.11	19
1972	11,404.88	6,694.15	19
1973	13,765.56	8,765.56	22
1974	14,311.56	9,311.56	22
1975	14,626.73	9,626.73	22
1976	15,814.81	10,442.59	22
1977	14,661.82	11,661.82	22
1978	19,833.01	16,833.01	25
1979	21,819.58	17,819.58	24

Revenue Act of 1964 reduced marginal income tax rates and narrowed the tax brackets, substantially increasing the progressiveness of the Federal income tax system. For example, the minimum marginal tax rate in 1963 was 20 percent, and each tax bracket increased at $2,000 intervals below $22,000 in taxable income. The minimum marginal tax rate was reduced to 14 percent in 1965, and the first four tax brackets were increased at $500 intervals.

The lack of progressivity in the tax system prior to the Revenue Act of 1964 allows the estimation of marginal income tax rates prior to 1962. Because the lowest marginal tax rate applied was to taxable income below $2,000, the appropriate marginal tax rate would be the one which corresponded to the lowest tax bracket. Therefore, the marginal tax rate from 1955 to 1961 was 20 percent. For 1964 and 1965, I used USDA data (*15*) for onfarm and off-farm income as a proxy for adjusted gross income; the estimated marginal tax rate for 1964 was 20 percent, and the tax rate fell to 17 percent in 1965.

Results

Rental rates for short-lived assets such as autos, trucks, and tractors are significantly higher than those for long-lived assets such as long-lived equipment and structures (table 5). The higher rental rates are primarily the result of shorter economic lives of the assets rather than of differences in tax treatment. The first major tax change during the period studied was the introduction of the investment tax credit in 1962. From 1961 to 1962, the rental rates fell from 0.1617 to 0.1489 for autos, from 0.1404 to 0.13 for trucks, from 0.1301 to 0.1236 for tractors (with a 9-year economic life), from 0.1029 to 0.0976 for tractors (with a 12-year economic life), from 0.0705 to 0.0656 for long-lived equipment, and from 0.0592 to 0.0533 for crop storage structures. The fall in rental rates for autos and trucks was also moderated by the required use of a minimum 8-year tax life to qualify for the entire 7-percent credit. Because the benefits of the credit outweighed the cost of selecting the longer life, I assumed that the tax lives of autos and trucks were increased from 6 to 8 years. Unitary livestock facilities and multipurpose structures were not eligible for the investment tax credit when it was first introduced in 1962.

In 1969 and 1970, the investment tax credit was repealed, and the rental rates for those assets which had previously qualified for the credit increased significantly. The rental rate for autos increased from 0.1417 in 1968 to 0.1510 in 1969, and the rental rate for trucks increased from 0.1312 to 0.1426. The rental rates for both tractor categories and long-lived equipment increased from 0.1384 to 0.1562, from 0.1081 to 0.1219, and from 0.0716 to 0.0797, respectively. The rental rates for unitary livestock facilities and multipurpose structures also increased from 1968 to 1969. However, these increases were a result of the rise in the price index of structures rather than the result of changes in tax laws.

In 1971, the investment tax credit was reinstituted, and unitary livestock facilities were added to the list of assets eligible to receive the credit. IRS also introduced the Asset Depreciation Range (ADR) system. Under the ADR system, tax lives could be reduced by as much as 20 percent. However, rising asset prices moderated the reduction in rental rates

Table 5—Implicit rental rates for farm equipment and structures, 1955-79

Year	Autos	Trucks	Tractors (9)[1]	Tractors (12)[2]	Long-lived farm equipment	Unitary livestock facilities	Crop storage structures	Multipurpose agricultural structures
					Rate			
1955	0.1408	0.1173	0.1062	0.0838	0.0567	0.0393	0.0554	0.0393
1956	.1418	.1216	.1055	.0824	.0551	.0369	.0548	0369
1957	.1497	.1299	.1124	.0880	.0588	.0381	.0558	.0381
1958	.1566	.1368	.1186	.0933	.0627	.0403	.0567	.0403
1959	.1617	.1419	.1241	.0978	.0660	.0411	.0573	.0411
1960	.1612	.1395	.1265	.0999	.0685	.0417	.0576	.0417
1961	.1617	.1404	.1301	.1029	.0705	.0433	.0592	.0433
1962	.1489	.1300	.1236	.0976	.0656	.0410	.0533	.0410
1963	.1470	.1282	.1247	.0983	.0661	.0411	.0538	.0411
1964	.1453	.1268	.1259	.0994	.0670	.0426	.0545	.0426
1965	.1426	.1265	.1268	.0999	.0672	.0424	.0553	.0424
1966	.1384	.1247	.1288	.1009	.0670	.0415	.0556	.0415
1967	.1410	.1285	.1342	.1053	.0705	.0448	.0591	.0448
1968	.1417	.1312	.1384	.1081	.0716	.0451	.0607	.0451
1969	.1510	.1426	.1562	.1217	.0797	.0492	.0723	.0492
1970	.1596	.1534	.1671	.1309	.0859	.0582	.0816	.0582
1971	.1621	.1563	.1625	.1281	.0846	.0604	.0824	.0650
1972	.1648	.1582	.1668	.1313	.0878	.0629	.0866	.0677
1973	.1520	.1489	.1603	.1233	.0789	.0525	.0808	.0564
1974	.1552	.1592	.1780	.1352	.0837	.0529	.0885	.0567
1975	.1783	.1854	.2180	.1696	.1130	.0703	.1014	.0781
1976	.1957	.2066	.2430	.1908	.1280	.0803	.1111	.0894
1977	.1997	.2154	.2581	.2008	.1308	.0784	.1140	.0872
1978	.2072	.2277	.2713	.2089	.1339	.0776	.1184	.0863
1979	.2121	.2367	.2884	.2186	.1335	.0694	.1182	.0768

[1]9-year economic life.
[2]12-year economic life.

caused by the investment tax credit and the shorter tax lives.

The importance of the investment tax credit is evident when one compares the rental rates for unitary livestock facilities and multipurpose structures. The rental rates for unitary livestock facilities increased from 0.0582 in 1970 to 0.0604 in 1971, while the rental rate for multipurpose structures increased from 0.0582 to 0.0650. Prior to the reintroduction of the credit in 1971, unitary livestock facilities and multipurpose structures received identical tax treatment; they were assumed to have the same economic lives, and their prices were equal. The only parameter which differed among the categories was that unitary livestock facilities were now eligible for the 7-percent investment tax credit.

In 1974, a high inflation rate (12.2 percent) boosted rental rates for all categories dramatically. Higher inflation rates increased rental rates by reducing the real value of the tax depreciation deductions and the investment tax credit. Inflation also produces a bias between short- and long-lived assets. Inflation affects short-lived assets more because a larger percentage of depreciation deductions are claimed earlier in the asset's life, reducing its real values by a greater amount. For example, from 1974 to 1979, the rental rate for both tractor categories increased from 0.178 to 0.2884 and from

0.1352 to 0.2186, while the rental rate for long-lived equipment increased from 0.0837 to 0.1335.

Estimated rental rates are significantly higher under a no-tax scenario (table 6). This situation does not imply that the tax system has actually reduced rental rates. Instead, the no-tax scenario reflects the higher real return to equity (8 percent) and, because the interest expenses are no longer deductible, the higher real interest rates which were used to discount future returns.[12] Table 6 also shows which asset groups have benefited most from the tax system. Prior to 1962, rental rates for each asset category except tractors averaged about 2-3 percent higher under the no-tax scenario.

From 1961 to 1968, rental rates are significantly higher under the no-tax scenario for each category, with rental rates for long-lived farm equipment and crop storage structures showing the largest increase. This dramatic change is a result of shorter tax lives and the introduction of the investment tax credit in 1962. Although multipurpose structures and unitary livestock facilities were not eligible for the investment tax credit, their tax lives were reduced from 50 to 25 years. This reduction raised rental rates by 7 percent in 1962 under the no-tax

[12]In a no-tax scenario, the appropriate rate of return to equity is a before-tax return. Therefore, I used an 8-percent real return to equity for the estimates in table 6 rather than the 6-percent real after-tax rate of return used for the rental rates presented in table 5.

Table 6—Percentage change in implicit rental rates under a no-tax scenario, 1955-79

Year	Autos	Trucks	Tractors (9)[1]	Tractors (12)[2]	Long-lived farm equipment	Unitary livestock facilities	Crop storage structures	Multipurpose agricultural structures
	Percent							
1955	2.56	2.22	0.19	1.31	2.65	2.80	1.81	2.80
1956	2.05	1.73	−.57	.61	2.00	3.52	1.09	3.52
1957	2.14	1.69	−.62	.57	2.04	3.41	1.08	3.41
1958	2.81	2.41	.42	1.61	3.35	3.23	3.00	3.23
1959	2.91	2.47	.48	1.74	3.33	3.16	2.97	3.16
1960	2.98	2.51	.47	1.70	3.50	3.12	3.13	3.12
1961	3.03	2.64	.69	1.94	3.55	2.77	3.38	2.77
1962	9.54	9.08	7.61	8.91	12.04	7.32	14.07	7.32
1963	9.46	8.97	7.46	8.75	11.95	7.30	14.13	7.30
1964	11.22	10.80	9.29	10.56	13.73	7.04	15.96	7.04
1965	11.15	10.67	9.23	10.51	13.69	7.78	15.55	7.78
1966	10.69	10.26	8.85	10.11	13.43	8.43	15.47	8.43
1967	10.78	10.35	8.72	10.07	13.48	8.04	15.74	8.04
1968	10.44	9.91	8.16	9.71	13.27	8.65	15.65	8.65
1969	4.17	3.16	−.26	1.23	4.77	9.35	7.19	9.35
1970	4.39	3.32	−.12	1.38	5.01	6.87	7.35	6.87
1971	10.92	10.36	9.42	10.93	14.54	15.40	16.87	7.23
1972	10.86	10.43	9.41	10.89	14.35	15.58	16.74	7.39
1973	9.34	8.73	7.55	9.25	13.81	18.10	16.96	9.93
1974	8.57	7.98	6.74	8.65	13.50	20.98	17.18	12.87
1975	14.58	13.92	12.16	13.97	16.73	20.63	21.50	8.58
1976	15.18	14.62	12.92	14.62	18.91	19.55	21.60	7.38
1977	14.62	13.97	12.20	13.99	18.43	20.66	21.32	8.49
1978	13.98	13.18	11.13	13.12	18.22	21.52	21.71	9.27
1979	12.68	11.96	9.71	11.89	17.75	25.65	21.83	13.54

[1]9-year economic life.
[2]12-year economic life.

scenario as opposed to a rise of only 3 percent in 1961. For autos, trucks, and tractors, tax lives were not reduced in 1962, but the investment tax credit caused 8-10 percent higher rental rates under the no-tax scenario. Long-lived farm equipment and crop storage structures benefited most from the 1962 tax changes. Tax lives for long-lived equipment were reduced from 15 to 10 years and from 25 to 10 years for crop storage structures. Both long-lived equipment and crop storage structures were eligible for the investment tax credit. Shorter tax lives and the investment tax credit boosted rental rates 12 and 14 percent, respectively, under the no-tax scenario for long-lived equipment and crop storage structures. These tax-induced advantages, measured in terms of rental rates, for equipment and crop storage structures continued through 1968. However, with the repeal of the credit in 1969 and 1970, the relative tax advantage shifted back toward unitary livestock facilities and multipurpose structures.

The investment tax credit was reintroduced in 1972, and unitary livestock facilities were added to the list of assets eligible to receive the credit. Tax lives for most assets were also reduced. As in 1962-68, the rental-rate advantage from 1971 to 1979 shifted back toward assets which were eligible for the credit. Assets such as crop storage structures, unitary livestock facilities, and long-lived equipment, which were eligible for both the credit and significantly reduced tax lives, benefited most under the tax system.

During 1955-79, Federal income tax policy greatly influenced rental rates among various farm assets. Although no one asset category benefited most in all years, specific tax incentives such as the investment tax credit have created incentives to purchase relatively greater amounts of certain assets (table 6). The investment tax credit with relatively short tax lives has dramatically changed rental rates; crop storage structures, unitary livestock facilities, and long-lived farm equipment have received the largest benefits.

Conclusions

The development of implicit rental rates for capital inputs is an important concept for understanding the effect of tax-induced changes on agricultural investment. Changes in tax laws may distort relative rental rates among various asset categories, increasing demand for assets which receive more favorable tax treatment and decreasing demand for assets which receive less favorable tax treatment. In the absence of other distortions, the resulting shift in investment decreases economic efficiency because the shift is a response to changes in tax laws rather than a response to market changes.

The results of this analysis are conditioned on the assumptions used to estimate the rental rates and the necessity to use proxy-type data because conceptually correct data do not exist. The implicit rental rates presented here are estimates of the true rental rates that would prevail under the given set of assumptions. These caveats notwithstanding, the weight of this analysis suggests that tax policy has indeed affected rental rates for farm equipment and structures, and, as demonstrated in the appendix, this conclusion holds over a range of assumptions about real rates of return and an alternative assumption about capacity depreciation.

More research is needed to determine the responsiveness of the food and fiber sector to changes in tax laws. Researchers need to incorporate implicit rental rates into a longrun dynamic optimization framework where short, intermediate, and longrun investment responses can be quantified. Given the fervor with which Federal income tax policy is employed as an incentive to spur investment, we need a broader understanding of how tax policy affects investment behavior.

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Appendix

I developed the implicit rental rates presented in appendix table 1 under the assumption of a "one-hoss shay" capacity depreciation pattern to test the sensitivity of the capacity depreciation assumption. The rental rates under the "one-hoss shay" depreciation pattern are significantly lower than those estimated under the double-declining balance method. For example, rental rates for automobiles ranged from 0.1408 to 0.2121 under the double-declining balance assumption whereas rental rates ranged from 0.0681 to 0.0945 under the "one-hoss shay" assumption. Although the "one-hoss shay" capacity depreciation assumption did affect the magnitude of the estimates, it did not significantly affect the ranking of the seven asset categories. Rental rates for autos, trucks, and tractors remained significantly higher than those for long-lived equipment and structures.

In addition to the capacity depreciation assumption, a second important assumption regarding the rental rates estimates is the required real after-tax return to equity. To test the sensitivity of this assumption, I also estimated rental rates for long-lived farm equipment with real after-tax returns to equity equal to 3 and 9 percent. Appendix table 2 shows the results of the alternative rates of return to equity. Rental rates estimated under a 3-percent real after-tax return to equity average about 10 percent lower than rental rates estimated under the 6-percent real after-tax return to equity assumption; rental rates estimated under the 9-percent assumption average about 10 percent higher than rental rates estimated under the 6-percent assumption.

Appendix table 1—Implicit rental rates for farm equipment and structures, 1955-79

Year	Autos	Trucks	Tractors (9)[1]	Tractors (12)[2]	Long-lived farm equipment	Unitary livestock facilities	Crop storage structures	Multipurpose agricultural structures
	Rate							
1955	0.0681	0.0565	0.0508	0.0405	0.0285	0.0239	0.0294	0.0239
1956	.0671	.0574	.0496	.0390	.0268	.0211	.0279	.0211
1957	.0712	.0616	.0531	.0418	.0288	.0221	.0287	.0221
1958	.0753	.0655	.0565	.0449	.0313	.0241	.0297	.0241
1959	.0781	.0683	.0593	.0473	.0332	.0249	.0303	.0249
1960	.0782	.0674	.0607	.0484	.0346	.0256	.0307	.0256
1961	.0788	.0681	.0626	.0501	.0359	.0269	.0318	.0269
1962	.0722	.0628	.0593	.0473	.0331	.0252	.0284	.0252
1963	.0710	.0617	.0596	.0475	.0332	.0250	.0285	.0250
1964	.0705	.0612	.0604	.0482	.0338	.0261	.0290	.0261
1965	.0689	.0608	.0606	.0482	.0337	.0257	.0292	.0257
1966	.0660	.0593	.0610	.0481	.0330	.0243	.0287	.0243
1967	.0675	.0613	.0637	.0504	.0349	.0265	.0308	.0265
1968	.0672	.0620	.0652	.0513	.0349	.0260	.0311	.0260
1969	.0712	.0671	.0733	.0574	.0385	.0280	.0367	.0280
1970	.0761	.0730	.0791	.0625	.0423	.0343	.0423	.0343
1971	.0784	.0753	.0778	.0619	.0425	.0369	.0438	.0397
1972	.0794	.0759	.0796	.0633	.0439	.0380	.0457	.0409
1973	.0697	.0683	.0736	.0565	.0365	.0271	.0387	.0291
1974	.0694	.0713	.0802	.0605	.0372	.0249	.0403	.0267
1975	.0838	.0869	.1020	.0797	.0535	.0390	.0507	.0433
1976	.0937	.0986	.1154	.0914	.0634	.0471	.0575	.0525
1977	.0938	.1010	.1207	.0943	.0628	.0432	.0567	.0480
1978	.0952	.1047	.1248	.0960	.0622	.0396	.0564	.0441
1979	.0945	.1057	.1295	.0974	.0590	.0315	.0529	.0348

[1]9-year economic life.
[2]12-year economic life.

Appendix table 2—Implicit rental rates for long-lived farm equipment under alternative real after-tax returns to equity, 1955-79

Year	$r_e = 0.03$	$r_e = 0.06$	$r_e = 0.09$
		Rate	
1955	0.0510	0.0567	0.0625
1956	.0494	.0551	.0610
1957	.0528	.0588	.0650
1958	.0566	.0627	.0691
1959	.0595	.0660	.0726
1960	.0619	.0685	.0753
1961	.0637	.0705	.0775
1962	.0593	.0656	.0721
1963	.0597	.0661	.0727
1964	.0605	.0670	.0737
1965	.0608	.0672	.0739
1966	.0604	.0670	.0738
1967	.0636	.0705	.0777
1968	.0644	.0716	.0790
1969	.0718	.0797	.0878
1970	.0776	.0859	.0945
1971	.0766	.0846	.0929
1972	.0793	.0878	.0965
1973	.0704	.0789	.0877
1974	.0743	.0837	.0935
1975	.0998	.1130	.1232
1976	.1153	.1280	.1411
1977	.1173	.1308	.1447
1978	.1194	.1339	.1491
1979	.1182	.1335	.1497

Beliefs of Farmers and Adoption of Integrated Pest Management

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Abstract

Georgia peanut farmers have adopted integrated pest management (IPM) on only a limited basis, although objective data indicate that IPM technology may be more efficient than conventional pest control strategies. Users and nonusers of IPM hold different views pertaining to the consequences of employing IPM. These beliefs influence its use. Educational programs on these beliefs should influence adoption and continued use of IPM. This article analyzes belief data pertaining to IPM among 192 Georgia peanut farmers and explores the relationship between beliefs about IPM and its adoption.

Keywords

Integrated pest management, risk, beliefs

Introduction

Integrated pest management (IPM) programs have recently expanded to encompass a multitude of crops. IPM programs are generally designed to optimally manage pest populations so that producers' profits are maintained or enhanced with minimal environmental degradation. Recent economic analysis indicates that peanut producers who employ a mean level of IPM have 34-percent higher profits and significantly lower insecticide expenditures compared with conventional pest control (*14*).[1] Despite this economic advantage, farmers have been relatively slow to adopt IPM; less than 40 percent of Georgia peanut acreage is currently under some type of IPM program (*9*). One popular explanation of this slow adoption rate is that response to risk impedes adoption of new practices (*5, 7, 27*). A previous study of IPM adoption in California investigated risk preferences and subjective probability distributions of IPM users and nonusers (*13*). The two groups indicated no differences in risk preferences, but each group perceived that its practice was the least risky.

This prominence of risk aversion in economic adoption literature reflects an attempt to explain behavior inconsistent with neoclassical microeconomics under certainty with an alternative economic theory. A potential weakness of this approach is that not all departures from neoclassical profit or utility maximization can be attributed to risk aversion (*25, 28*).

Risk aversion can be confused with behavior under certainty because of dynamic considerations (*3*), incomplete specification of resource constraints (*4*), dispersion of price expectations (*24*), and transactions costs for commodities which are periodically both inputs and outputs (*26*). Carlson recently concluded that risk aversion may not affect pest control decisions even though pest control does affect risk

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[1]Italicized numbers in parentheses refer to items in the References at the end of this article.

(*6*). In a broader view, neither profit maximization nor risk aversion may be the most important goals in pest control. Economists often tend to use their theory to explain behavior motivated by goals and constraints outside the realm of economics. Dillon, a pioneer in risk analysis in agricultural economics, endorses this view in reference to the relationship between risk and economic development:

> Most people would agree that uncertainty prevails in underdeveloped agriculture and that development would be facilitated by an appreciation, understanding and recognition of this uncertainty. While not disagreeing with this assessment, my view, however, is that uncertainty is not a major detriment to agricultural development. It is far overshadowed by the influence of political goals, resource ownership, human capital stock, social power, tradition, and ignorance. Compared to these, uncertainty is just a marginal element in most less developed countries. We do best to recognize uncertainty, of course, but we delude ourselves if we think of it as a key factor to development except in countries where occasional crop failures on a grand national scale are not expected (*8*, p. 37).

Literature on goals of U.S. farmers also supports the existence of noneconomic goals (*23*). Thus, a study of the importance of economic goals in the adoption of IPM should also include other broader goals for comparison.

The purpose of this article is to present an interdisciplinary study of the relationship between risk and other perceptions of farmers and their adoption of IPM. Working with entomologists and psychologists, we identified potentially important economic and other consequences of decisions on pest control related to IPM. We represented these aspects as "belief measures," a psychological concept. We collected belief data on IPM, including a risk measure, for Georgia peanut producers in a 1982 telephone survey.

The Concept of Beliefs

Beliefs are defined as information one holds about a particular object and are different from a related term, attitudes. Attitudes are affective or emotional responses one has toward an object. For example, the statement "I do not like IPM" is an attitude; "IPM increases returns" is a belief. Although theoretical constructs are often difficult to reconcile among different disciplines, attitudes are similar to the economic concept of preferences, and beliefs are similar to the concept of expectations including subjective probability distributions (*20*). Belief measures have at least two advantages for this study. First, the concept is flexible enough to encompass both economic and other perceptions about IPM. Measurement of beliefs has extensive psychometric foundations and is not subject to the empirical problems of the conventional economic measures of risk preferences and subjective probability distributions.[2]

The psychological literature has two alternative theories concerning the relationship between beliefs and behavior. *Learning theory* espouses the view that beliefs underlie attitudes which, in turn, motivate a response or behavior (*12*). For example, the belief that IPM increases returns leads to a positive attitude towards IPM and eventual adoption. *Cognitive dissonance* is the second theory about the relationship between beliefs and behavior. A central proposition of this theory is that holding attitudes and beliefs inconsistent with current behavior is discomforting. These attitudes and beliefs are modified to become consistent with current behavior (*11*). Cognitive dissonance theory implies that beliefs may not explain use of IPM, but may instead reflect a rationalization of current behavior. Under this theory, differences in beliefs would not explain adoption.

Assuming that IPM is more profitable than are conventional control methods, users may have adopted IPM, under learning theory, because they gained in-

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[2]Musser and Musser recently reviewed the literature on problems in eliciting risk preferences and probability distributions in relationship to psychological theories on risk decisions (*20*). The main empirical problems are instability of the measures at different times and lack of evidence on the relationship between these measures and behavior. Problems with these procedures are not surprising considering the current psychological evidence that individuals are poor intuitive statisticians. For example, individuals tend to overweight current or otherwise very salient outcomes over more distant outcomes, and they do not consider prior information such as suggested by Bayes Law. Furthermore, they overweight unlikely events and underweight more likely events. Agricultural economists have been aware of this literature for some time (*2*). However, they have not fully appreciated the implications of the literature on economic methodology. Kahneman and Tversky provide a recent introductory survey of some of this literature (*16*).

formation from educational materials or observations of other farmers, causing them to develop positive beliefs about IPM. However, farmers who have not adopted IPM have not developed these same positive beliefs because they lack access to or trust in the information about IPM. In contrast, cognitive dissonance would imply that these respective beliefs did not motivate adoption behavior, but arose *ex post facto* to rationalize behavior in a consistent manner.

The learning approach is more consistent with the perspective of economic theory and the whole rationale of the agricultural land-grant system. Under this view, an investigation of beliefs among IPM users and farmers who practice conventional control methods may reveal differences in beliefs that could be used to design an educational program to modify beliefs and, therefore, to change behavior. In contrast, the cognitive dissonance approach suggests limited usefulness of an educational program to change behavior. Beliefs about and support for IPM would change after IPM was adopted. Adoption may require coercion through the political-legal system or some stronger economic incentives such as subsidies.

As with all theories, both theories are abstractions of human behavior, and both may operate at different times. For example, a positive belief may motivate behavior which in turn motivates a more positive belief towards the behavior. Alternatively, some beliefs about an object may motivate behavior towards that object, whereas other distinct beliefs may adjust rationalization to behavior. Given the considerable differential relevance of the two theories for public programs on IPM adoption, it is important to distinguish the process involved in the belief formation. Testing the alternative theories of IPM is unfortunately difficult in a cross-sectional study such as this article. Under the learning approach, IPM users should have more positive beliefs about the benefits of IPM than do nonusers, who practice conventional methods, because beliefs influence behavior. However, user and nonuser beliefs would adjust to the same pattern for rationalizing behavior under cognitive dissonance. Hanemann and Farnsworth recognize these alternative explanations of their cross-sectional study of IPM adoption (*13*). Standard methodology to measure beliefs does provide measures of support for various beliefs, which may provide some support for alternative theories. For example, positive beliefs about IPM among nonusers is inconsistent with cognitive dissonance.

Further dividing farmers into present users who are currently using IPM, past users who have discontinued use of IPM, and nonusers who have never used IPM may provide additional evidence for these alternative theories. The behavior of past users is an interesting issue. If IPM is, in fact, more profitable, then past users were not able to recognize this fact, ignored the information, or had inadequate management to implement IPM. Under learning theory, this process led to more negative beliefs and the reemergence of conventional methods; of course, these beliefs would adjust after the behavioral change under cognitive dissonance. However, cognitive dissonance implies that beliefs of past users would be in the interval between beliefs of present users and nonusers. Beliefs of past users would be more negative than beliefs of present users to rationalize their current behavior, but would still be more positive than beliefs of nonusers because of their need to rationalize past behavior. Under learning theory, a less clear prediction is possible. Past users discontinued IPM because the beliefs that motivated adoption became less positive; thus, their beliefs should be more negative than present users. Although the beliefs of past users may be as negative as those of nonusers, some may have more positive beliefs than nonusers, which could result in a similar pattern for these groups as does cognitive dissonance. However, a different pattern of beliefs could also hold under learning theory. The experience with IPM provided past users with more information about both alternatives, which causes their beliefs to become even more negative than nonusers. Thus, an intermediate positive for past users provides no evidence on the two theories, but the more negative beliefs of past users supports learning theory.

A complete testing of the alternative theories would require time series data on beliefs of each group. Under learning theory, beliefs of present users would be higher than those of nonusers before adoption, and beliefs of past users would be lower than those of present users before discontinuation. Under cognitive dissonance, these differences would not exist before behavior changes but would arise only after behavior change. Although such time series

data were unavailable for this study, the number of years present users have used IPM was available and could provide some evidence on this relationship. As more time elapses, present users should develop a more positive attitude towards IPM under cognitive dissonance to rationalize continued use. A similar relationship could exist under the learning theory if IPM fulfilled expectations. However, the opposite pattern is also consistent with learning theory. Unfulfilled expectations would lower the initial level associated with adoption; if these beliefs decline to a certain point, present users would become past users. Thus, changes in belief among present users through time can reject the cognitive dissonance explanation if beliefs are inversely related to tenure, but these changes cannot definitively reject the learning explanation.

Even if the relationship between beliefs and adoption cannot be established, analyzing differences in beliefs among users and nonusers provides evidence on the importance of different dimensions of IPM programs for the different groups. Beliefs that are more strongly held, as measured by differences between the two groups, are relevant for farmers either in explaining or rationalizing behavior. For example, the differences in risk perceptions found in Hanemann and Farnsworth indicate that their sample is motivated by risk aversion (*13*). If no differences were found or if the reverse pattern held, the study would have supported the view that risk aversion is not important.

Data

This study on beliefs was part of a larger study which evaluated the IPM program sponsored by the Department of Extension Entomology of the Georgia Cooperative Extension Service. The most important component of the program involved periodic insect counts by scouts and treatment recommendations based on damage thresholds. Present, past, and nonparticipants in extension IPM were considered present users, past users, and nonusers, respectively, for our study, even though some farmers in Georgia practice IPM outside this program (*9*).

We obtained belief data on IPM for a stratified random sample of peanut producers in six Georgia counties selected from a list of Georgia peanut producers provided by the Georgia State Office of the U.S. Agricultural Stabilization and Conservation Service. From a sample of 240 producers, 192 (80 percent) cooperated in completing a telephone survey. The survey, developed by a team of entomologists, cooperative extension county agents, agricultural economists, and industrial psychologists, was conducted in late spring-early summer of 1982.

The survey required several months to devise. Each question was evaluated in terms of its contribution to obtaining the desired information on pest management practices. The questionnaire was pretested at several stages of development, with confusing or misleading questions being clarified or deleted. A copy of the final questionnaire is available in Edwards, Musser, and Wetzstein (*10*).

Nine students enrolled at the University of Georgia conducted the interviews. Prior to the interviews, the students were provided with an explanation of the questionnaire and its purpose, given appropriate standard answers to probable questions, practice, and feedback. Calls were occasionally monitored and appropriate feedback given. The students placed the telephone calls in the early evening from Sunday through Thursday. The questionnaire contained 46 questions and required slightly less than 30 minutes to complete.

Table 1 lists both the eight belief questions included on the questionnaire and variable names for reference. The belief questions focused on aspects of insect control as important in managerial decisions on IPM use. These questions must be interpreted within the context of the whole questionnaire where users of IPM were considered as participants in the extension scouting program and nonusers apply pesticides on a fixed schedule. "Damage" and "yield" are concerned with monetary costs of insect control, and "profit" is associated with overall profit from use of IPM. "Risk" reflects a safety-first concept of risk which is generally more intuitive than are more general measures like variance associated with expected utility theory (*21*). "Personnel" and "environmental" were aspects of the use of IPM programs not directly reflected in profit calculations, but they may be important in the managerial process. "Method" was included largely as a methodological check on communication with the producer because the belief corresponds with the actual use of IPM for peanuts in Georgia.

Table 1—Belief measures

Belief variable	Questions[1]
General statement	I'd like to ask for your opinions on pest control strategies. These questions will ask you whether you strongly agree, agree, disagree, or strongly disagree with them. There are no right or wrong answers; these are only your opinions.
Damage	The likelihood of insect damage is lessened with the use of scouts. Do you: SA A D SD
Expense	It is less expensive to pay scouts to monitor my fields than spraying on a predetermined schedule. Do you: SA A D SD
Personnel	Hiring my scouts on a personal basis rather than going through my county extension program best serves my needs. Do you: SA A D SD
Yield	Farmers can expect higher average yields by spraying on a predetermined schedule rather than using scouts. Do you: SA A D SD
Environmental	The use of insecticides poses a harmful environmental threat. Do you: SA A D SD
Method	In my county the most widely used method of pest control is spraying on a predetermined schedule. Do you: SA A D SD
Profit	Some people argue that IPM produces higher profits. Others strongly disagree. Do you: SA A D SD with the following statement? Conventional pest management strategies give farmers higher profits.
Risk	People disagree about the differences in yield produced by integrated pest management (IPM) vs. conventional pest management strategies. Some argue that IPM produces better average yield over a period of years. Others say the same for conventional methods. Do you: SA A D SD with the following statement? IPM reduces the chances of having extremely low-yielding years.

[1]In the questions, strongly agree, agree, disagree, and strongly disagree are coded as SA, A, D, and SD.

To facilitate telephone responses, interviewers gave respondents one of four choices when they answered the questions: (1) strongly agree, (2) agree, (3) disagree, and (4) strongly disagree. These responses were coded 4, 3, 2, and 1, respectively, for statistical analysis, and they were assumed to reflect measurements of continuous theoretical variables.

The assumption in the coding that these responses reflect equal intervals along an underlying scale is standard methodology in psychometrics (*1*). The questions were counterbalanced to preclude a response bias because "strongly agree" is the most positive response to IPM on all beliefs. "Strongly agree" is the most positive for the categories of damage, expense, environmental, and risk, whereas "strongly disagree" is the most positive for personnel, yield, and profits. Questions included in the survey concerned use of IPM in the current year and in past years. These questions were used to

separate respondents into present user, past user, and nonuser groups. Data on tenure of the farmers in IPM were available for only four of the six counties, so analysis of possible changes in IPM beliefs through time were confined to a subset of the sample.

Results

We first applied a multivariable analysis of variance (MANOVA) to the eight belief variables. MANOVA tests the hypothesis of a common set of means for the eight variables in the three producer IPM groups (*19*). The MANOVA F test was significant at the 1-percent level; thus, the hypothesis of common means can be rejected. We then used analysis of variance (ANOVA) of each belief variable by IPM use group to determine which variables contributed to the MANOVA result. Table 2 summarizes the ANOVA results along with mean responses for each producer group.

The damage, expense, personnel, and yield variables were directly concerned with the use of insect scouts, which is the most important component of IPM programs in Georgia. The expense question had different responses among the groups significant at the 10-percent level, and the other three variables had differences significant at the 1-percent level.

Present users believed that scouting reduced insect damage, was less expensive, and resulted in higher yields. Although the beliefs of present users differ significantly from the other two groups, the mean response for all producers indicated that they either agreed or strongly agreed that scouting reduced damage and was less expensive. For the yield questions, present users disagreed that higher yields resulted from spraying on a predetermined schedule rather than from using scouts; mean values of the other two groups lay between disagree and agree.

Table 2—IPM belief results, by user group

Belief	Mean value			ANOVA F statistic	Significance level[1]
	Present user	Past user	Nonuser		
Damage[2]	3.23	3.08	2.93	6.98	0.0012***
Expense[2]	3.39	3.23	3.06	2.66	.0727*
Personnel[3]	2.42	2.73	3.30	5.14	.0067***
Yield[3]	1.95	2.65	2.43	5.85	.0035***
Environmental[2]	2.31	2.50	2.72	1.85	.1607
Method[4]	2.60	2.73	2.72	.23	.7936
Profit[3]	2.22	2.62	2.72	6.16	.0026***
Risk[2]	3.07	3.77	3.54	3.27	.0404**
Number of producers	106	26	54	NA	NA

NA = Not applicable.

[1] * = Significant at the 10-percent level;
** = Significant at the 5-percent level; and
*** = Significant at the 1-percent level.

[2]Large number indicates positive belief about IPM.

[3]Small number indicates positive belief about IPM.

[4]This variable is a methodological check on communication with the producer. The magnitude of the number indicates no level of belief about IPM.

Thus, the effect of insect control on yields seemed to indicate more important differences than did the components measured by these other three variables.

The profit question also produced differences among the groups significant at the 1-percent level with group patterns similar to the yield question. Users disagreed that conventional pest management strategies give farmers higher profits, whereas past and nonusers generally tended to agree more with this statement. The mean responses to expense, yield, and profit questions indicate that the differences in beliefs on profits associated with IPM use arose from differences in yields and revenues rather than costs. These beliefs only partially correspond with economic analysis of IPM use by Georgia peanut farmers. In their study of IPM use in Georgia peanut production, Hatcher, Wetzstein, and Douce found a significant reduction in insecticide cost, which corresponded to beliefs of all groups, and a significant increase in yields, which is consistent only with the beliefs of users (*14*).

For the risk question, all groups tend to agree that IPM reduces the chances of having extremely low-yielding years. In fact, past users and nonusers generally believe more strongly that IPM reduces variability. Differences between these groups were significant at the 5-percent level. These results sharply contrast with the previous findings of Hanemann and Farnsworth (*13*). Because belief measurement has fewer methodological problems than does elicitation of subjective probabilities, the findings of this article are credible. If the risk responses are interpreted jointly with the profit responses for each group in isolation, they seem plausible with expected utility theory. Users adopt IPM because they believe it raises average profits and lowers risk, whereas the other group does not adopt IPM because the sacrifices in expected profits does not compensate for the decreased risk. However, the pattern of risk responses among the groups is difficult to rationalize. Assuming producers are risk averse, the risk responses are definitely inconsistent with cognitive dissonance; users have a less positive view than do the other two groups. Although these beliefs might be consistent with learning, they do not explain the behavior. Profits alone explain behavior as well as profit and risk, suggesting that risk is not important in explaining the use of IPM.

If one relaxes the assumption of risk aversion, responses to the risk question are consistent with farmers' being risk seekers. Under this assumption, the low value for present users' risk response would be a positive belief in IPM, the higher value for nonusers' risk respond would be a negative belief, and the even higher value for past users' risk response would be a negative belief arising from learning behavior. As Young notes, past studies measuring risk preferences found some farmers' being risk seekers (*28*). However, the complete sample would probably not be dominated by risk-preferring behavior. Furthermore, the interest in risk in the adoption literature is motivated by an assumption of risk aversion; that is, risk seekers would readily adopt new technology perceived as being risky. This assumption does not seem a plausible method of interpreting risk. The results support the general view emerging in the literature reviewed in the introduction to this article—namely, risk is not important in the IPM adoption decision.

The method and environmental questions did not significantly differ among the groups. The mean responses to the method question were similar and indicated a tendency to agree. These responses indicated that producers had some knowledge of current pest control methods and that respondents were serious in their responses to at least this survey question. All groups had mean responses to the environmental question that were neutral; the mean responses had as much difference as some of the other variables, but had high variances as reflected in the F statistic.

Mean responses for past users were within the interval between present users and nonusers for most variables. Exceptions were the yield and risk questions. Past users tended to agree that higher yields resulted from spraying on a predetermined schedule rather than from using scouts, with a mean response of 2.65 compared with 2.43 for nonusers and 1.95 for present users. Past users strongly agreed with a mean response of 3.77, compared with 3.07 for present users and 3.54 for nonusers, that IPM reduces the chances of having extremely low-yielding years. Thus, past users believe that not practicing IPM will boost average yields and promote greater yield variability than do the other groups. The response on risk is again not consistent with their status as past users under either learning or cognitive dissonance. The yield response contradicts cognitive dissonance and suggests that

experience with low yields contributed to past users' abandonment of IPM. Their management ability may have precluded implementing IPM practices, and their belief may have reflected this experience. This belief may have resulted from spurious correlation; the series of recent droughts in Georgia was probably the main reason for lower yields. Good extension information may have precluded formation of and action on this belief.

Besides responses from past users on yield and risk, overall responses to some variables also support learning theory. The nonusers' mean response of 3.54 on risk does not suggest reduction of cognitive dissonance. Similarly, nonusers' mean response of 2.93 on the damage question and 3.06 on the expense question indicates that they agreed with positive statements about IPM which is inconsistent with their behavior. The mean response of 2.42 on the personnel question for present users is also not consistent with current behavior. Finally, the largely neutral mean responses with large variances to the environmental question are inconsistent with cognitive dissonance; more consistent tendencies on this belief could have been a rationalization for behavior unrelated to profits of the business. No evidence on profit, which does have large differences among groups, is available, unfortunately.

We used linear regression analysis of beliefs of the present user groups to provide further evidence on the relationship between beliefs and behavior. We regressed the eight belief measures separately on the number of years a present user had participated in IPM. Data were available for 52 IPM users in four counties in 1979-82. We included county dummy variables in the regression analysis to account for possible differences in climatic and soil conditions. Table 3 gives the regression results. As previously discussed, a negative coefficient on years of IPM use is inconsistent with cognitive dissonance where "strongly agree" indicates a positive belief about IPM, and vice versa.

The regression analysis was not highly satisfactory. The R^2's were extremely low, even for cross-sectional regressions. None of the county dummy variables differed significantly from zero, indicating no geographical differences in beliefs between these three counties and the county with no dummy variable. Years of IPM use was significant at the 5-percent level in the damage equation. This negative coefficient indicated that the belief that the likelihood of insect damage is lessened with the use of scouts declined through time for users, which was inconsistent with cognitive dissonance. The coefficient on years of IPM use did not differ significantly from zero in the other equations. Furthermore, the signs of these coefficients do not prove the alternative theories in most cases.

Conclusions

Results support the view from earlier research that IPM users and nonusers hold different views about the consequences of IPM use. As expected, users of IPM hold more positive beliefs about IPM than nonusers, except one. The single exception concerned risk which, contrary to earlier research, had a reverse pattern. Because no theoretical explanation exists for the response pattern obtained on the risk question, these results suggest that beliefs about risk are not related to adoption of IPM. However, beliefs on average yields probably influence adoption and continued use of IPM. Although no direct evidence existed that beliefs on average profits influenced adoption of IPM, the predominance of evidence against cognitive dissonance processes for the other beliefs supports the view that the differences in beliefs on average profits also affect adoption. Thus, the results support the emerging trend in agricultural economics literature that profit maximization may explain much economic behavior formerly attributed to risk aversion. More research on this issue in reference to IPM seems warranted.

Results in tables 2 and 3 also support the view that beliefs about IPM influence adoption rather than reflect a cognitive dissonance response. Under this view, processing information correctly may influence beliefs and, therefore, adoption. These results directly affect the Cooperative Extension Service's National IPM Impact Study, which was designed to evaluate IPM programs in various States. This impact study outlines in detail the possible advantages of IPM over conventional practices. Our study indicates that the National IPM Impact Study can positively influence producers' adoption of IPM.

The psychological literature also suggests some methods to influence incorrect beliefs. Hovland,

Table 3—Regression results for belief and years of use for present users[1]

Belief measure	Intercept	Years of IPM use	County dummies			R^2
			1	2	3	
Damage[2]	4.00** (14.16)	-0.19* (-2.44)	0.23 (1.16)	0.06 (.27)	0.11 (.50)	0.16
Expense[2]	3.25** (11.42)	.06 (.70)	.15 (.72)	.18 (– .79)	.40 (1.74)	.12
Personnel[3]	2.29** (3.98)	– .04 (– .26)	– .29 (– .71)	– .13 (– .30)	.52 (1.12)	.08
Yield[3]	1.81** (3.28)	(– .05) (– .31)	.58 (1.47)	.54 (1.23)	.02 (.04)	.07
Environmental[2]	2.26** (5.73)	– .05 (– .42)	– .50 (–1.50)	.17 (.46)	.52 (–1.38)	.11
Method[4]	3.45* (4.94)	– .23 (–1.20)	5.97 (.00)	.04 (.06)	– .82 (–1.46)	.08
Profit[3]	2.69* (7.16)	– .06 (– .61)	.19 (– .70)	– .004 (– .01)	– .42 (–1.38)	.05
Risk[2]	1.96** (2.84)	.23 (1.21)	.15 (.30)	.28 (.50)	1.10 (1.98)	.11

NA = Not applicable.
** = Significant at the 1-percent level.
* = Significant at the 5-percent level.
[1]t-values appear in parentheses.
[2]Large number indicates positive belief about IPM.
[3]Small number indicates positive belief about IPM.
[4]This variable is a methodological check on communication with the producer. The magnitude of the number indicates no level of belief about IPM.

Janis, and Kelley suggest that correct information that is different from original beliefs must be provided in a way that incentives for change are provided (*15*). Such incentives might be a change in either the content of a message about the belief object or a perception about the expertise or prestige of the communicator. The recent emphasis on IPM evaluation by agricultural economists could provide these new incentives. Profit is probably a stronger motivator for farmers than are insect damage or environmental concerns about insecticide use. Furthermore, the perceived expertise of agricultural economists is important in reinforcing the expertise of entomologists involved in IPM programs.

Assessing IPM beliefs would be helpful in identifying incorrect beliefs of nonusers so as to develop educational programs which could change behavior. Furthermore, such an assessment might document the importance of both entomologists and agricultural economists in the evaluation and education program. Data in table 2 demonstrate these propositions. Beliefs of nonusers can be modified by evidence that field scouting tends to decrease crop damage and pesticide expenditures and to increase yield and net returns, both areas of entomological and economic expertise. Changing these beliefs may help encourage adoption. Information about the effect of IPM on average yields may renew the interest of past users in IPM. Finally, reinforcing beliefs of present users with information about the consequences of IPM is important to maintaining IPM use. We should place particular effort on developing and disseminating information about differences in yield and profits, the two beliefs about which

significant disagreement existed between users and other groups.

Use of psychometric methodology to understand farm management decisions has potential in other areas beyond IPM programs. Psychological methodology has had limited use in agricultural economic research on farm firm decisions. Krause and Williams (*18*), and recent work by Klieberstein and others (*17*) and by Patrick, Blake, and Whitaker (*22*), on modeling multiple goals are exceptions. However, many adoption problems in agricultural production are similar to the IPM issue we discuss here. Adopting new technologies to facilitate agricultural development, which was the concern of much of the risk literature we reviewed in the introduction, is an obvious extension. Several issues of public concern in farm management may also be amenable to similar research; soil conservation, water conservation, and marketing strategies are several examples. Assessment of beliefs about adoption establishes the relevance of different forms of economic information in planning research and extension programs.

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Public Policy and the Reemergence of International Economic Influences on U.S. Agriculture

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Abstract

Recent literature on agricultural policy argues that a new market environment has emerged in the past 15 years characterized by the growing importance of international trade, a U.S. agricultural sector increasingly integrated into the U.S. and world macroeconomy, and an increasing price variability for agricultural commodities. A historical examination of the effects of trade, macroeconomic factors, and price variability on U.S. agriculture, however, shows that these influences are not new. Changes in agricultural and macroeconomic policies in the seventies have caused these characteristics to reemerge, albeit in a somewhat different form and magnitude than in previous decades.

Keywords

Agricultural policy, agricultural trade, macroeconomic influences, price variability

Introduction

Current literature on agricultural trade characterizes the international environment facing U.S. agriculture with three generalizations: (1) that trade plays an increasing role in U.S. agriculture; (2) that U.S. agriculture is increasingly integrated into the U.S. and world macroeconomy; and (3) that price variability for agricultural commodities is increasing (see Duncan and Borowski (*8*) for one example).[1]

These generalizations imply that international trade was not, until recently, very important to U.S. farmers and that the agricultural sector was largely isolated from the rest of the economy. Furthermore, the last statement implies that price variability due to the reliance on exports is a new problem for the sector. Economists have used these generalizations to argue in favor of a new U.S. policy to deal with this international environment.

A longer perspective, however, shows that these influences are not new, although the magnitude of these influences and the manner in which they affect agriculture may have changed. Except for two or three decades in the middle of this century, international trade has been critical to the well-being of the agricultural sector, agriculture has been sensitive to developments (shocks) elsewhere in the economy, and prices for farm outputs have been highly variable. The theme of this article is that changes in public agricultural and macroeconomic policy during the seventies allowed these elements to reemerge, albeit in a somewhat different form and magnitude than in previous decades.

Formation of future policies requires an understanding of how U.S. policy and the international environment have interacted in the past. In this article, we will broadly compare and contrast the international environment facing U.S. agriculture. We will separate influences which have reemerged from those we believe have changed. We will then attempt to link the role of trade and the variability in prices to the policy behavior of the U.S. Government.

We will identify four distinct periods of U.S. policy responses to the international environment. The first period, up to 1930, was a period of indirect Government intervention in agricultural commodity

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[1]Italicized numbers in parentheses refer to items in the References at the end of this article.

markets and of limited intervention in the macroeconomy. The period was characterized by an important role for trade, variable agricultural prices, and strong agricultural linkages to the macroeconomy.

During the next period, 1930-70, the U.S. Government assumed a major direct role in agricultural commodity markets and the macroeconomy. Trade's importance to U.S. agriculture was relatively small compared with domestic demand, price variability was reduced, and macroeconomic policy concentrated on aggregate demand management.

In the third period, 1970-80, changes in U.S. Government agricultural and macroeconomic policy allowed the international environment which faced U.S. agriculture in the past to reemerge. Agricultural commodity programs changed from price support using nonrecourse loans to income support via deficiency payments. Macroeconomic policy during this period became more chaotic and less able to manage aggregate demand.

In the last period, 1980 to the present, agricultural policy has shifted as policymakers attempt to operate in this reemerged environment. A critical policy issue is the type of public intervention strategy the United States should elect.

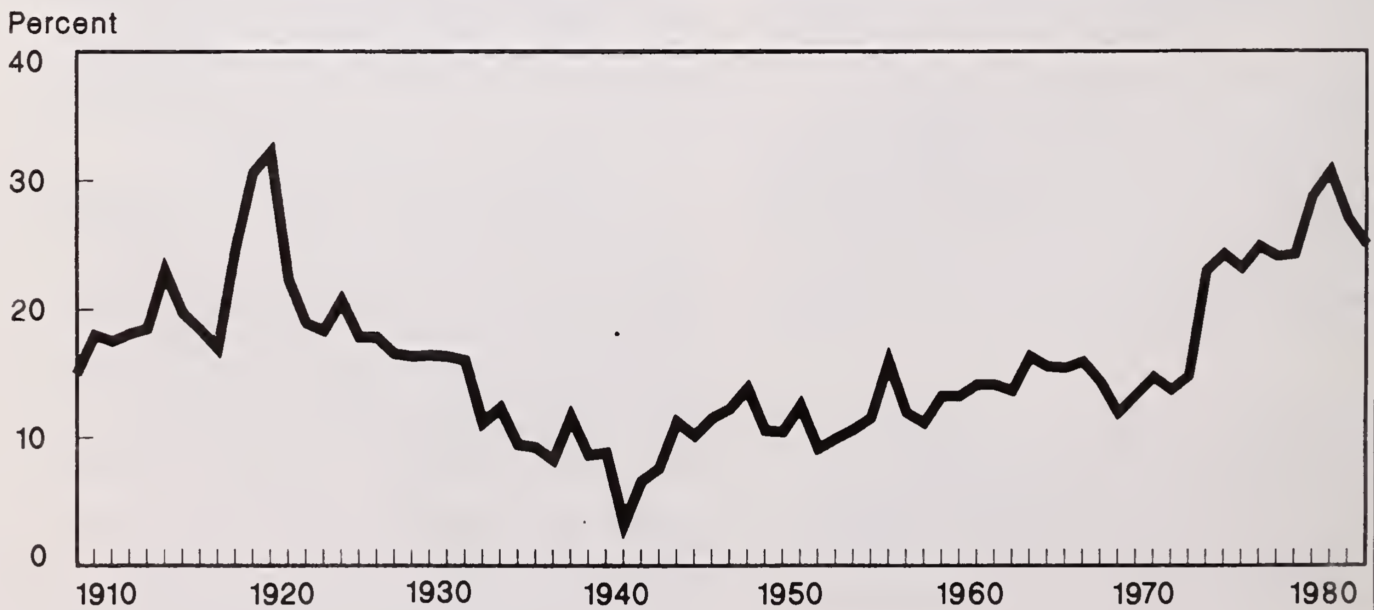
The longer run perspective discussed in this article shows that the United States had confronted these issues before and adopted two contrasting means of reacting to this international environment. One policy allows the domestic market to adjust to changing world market conditions, whereas the other prevents such adjustment through public intervention. Consideration of the historical experience of each policy strategy should provide insights into the direction of future policies.

Role of Trade

Except for a few decades of this century, trade has been critical to U.S. agriculture. It has been an important outlet for production and has been a source of instability for agricultural prices. Figure 1 shows that it was not until the seventies that agricultural exports as a percentage of farm cash receipts regained the levels obtained during the 1910-29 period (*6*). Tobacco was a major export since the early

Figure 1

Agricultural Exports as a Percentage of Cash Receipts



settlers arrived. With the invention of the cotton gin in 1793, cotton became a major export; in 1860, cotton constituted almost two-thirds of the total export trade of the United States (*18*). Historians argue that one of the major causes of the Civil War was the conflict between the agricultural export-oriented South and the manufacturing protectionist North. One author describes the situation in agriculture as: "During and after the Civil War the fluctuations of the currency and the high tariff worked especial hardship on the farmers as producers of staples which must be sold abroad..." (*3*, p. 20). Although this situation applied primarily to southern cotton and tobacco farmers, it was of growing importance to northern wheat producers as well. This quotation illustrates three concerns which sound familiar today: (1) currency fluctuations (inflation and exchange rates) (2) high U.S. tariffs (on nonagricultural goods) and (3) importance of export markets. The period following the Civil War was one of agricultural expansion, increased communication, and improved transportation, all of which encouraged international trade (*7*). The arrival of North American grain on European markets in the late 1870's was partially responsible for reconciling industrialists and agricultural interests in Germany, leading to Germany's tariff of July 1879 (*9*, p. 297). The recession which hit agriculture in 1921 was both the result of a decline in exports following World War I as European nations recovered from the war as well as the result of overexpansion in U.S. agricultural production to wartime needs.

Table 1 shows the average share of production exported for current major U.S. agricultural exports by decade since 1870 on a volume basis. The pattern is generally U-shaped. Prior to the thirties, trade was important for wheat, cotton, tobacco, and rice (*7*). The trough in the thirties reflects the tariff wars during the Depression, whereas the low values for the forties reflect the interruption of commerce during World War II. During the postwar period, the role of trade began to rise.

Wheat exports in the 1870-1929 period averaged 26 percent of production. During the thirties that share fell dramatically to 8.4 percent. Only after the passage of export subsidies and export promotion programs during the fifties did the export share of wheat production recover. The export share of wheat production rose to a peak of 58.1 percent in the seventies, but it fell slightly in the early eighties. Similar patterns over time are evident for corn and cotton, despite the fact that most of the corn was used onfarm wheras the cotton was marketed. Corn exports in the fifties were about the same share of production as during the 1870's. Corn exports in recent years have risen to 24 percent of production, about the same share wheat exports had in the 1870's. Although cotton exports as a share of production have risen, exports are still well below

Table 1—Average share of U.S. production exported for selected crops, by decade, since 1870

Decade	Wheat	Cotton	Tobacco	Corn	Soybeans	Rice
			Percent			
1870-79	25.4	64.7	59.1	4.4	[1]	[2]
1880-89	26.9	65.6	45.3	3.1	[1]	[2]
1890-99	30.1	68.6	37.3	5.3	[1]	[2]
1900-09	22.0	67.1	35.4	2.8	[1]	[2]
1910-19	23.5	57.6	37.0	1.8	[1]	16.5
1920-29	26.0	57.5	38.8	1.3	[1]	26.0
1930-39	8.4	50.9	31.4	1.6	6.7[3]	16.6
1940-49	18.7	23.1	22.4	2.0	2.8	42.7
1950-59	35.9	35.7	23.6	4.5	16.3	49.6
1960-69	53.6	35.0	26.1	12.4	28.1	61.2
1970-79	58.1	41.2	36.7	24.4	38.3	58.9

[1]Soybean production and trade data not reported prior to 1931.
[2]Rice production and trade data not reported prior to 1910.
[3]Nine-year average used.
Source: (*18*).

the contribution made in earlier periods. Tobacco exports were well below historical levels. Trade has become increasingly important to soybeans and rice.

Depending on when the comparison is made and what crop is considered, one can view the current large share of production exported as either a fundamental change or a reemergence of what existed before the thirties. For wheat, export trade was always important, but its contribution has risen. Trade is clearly more important for corn, soybeans, and rice. Exports for cotton and tobacco are less important than they were 50 or 100 years ago.

The figures do suggest some major changes during the intervening years. Foremost, the mixture of crops exported has changed. Wheat, cotton, and tobacco have given way to corn and soybeans. Unlike the pre-Depression years, the emphasis of U.S. export trade is more toward ingredients for livestock feed. Because meat demand tends to be more sensitive to income changes than is the demand for the wheat, rice, cotton, and tobacco, U.S. trade may be more sensitive to changes in income growth than in the past. Another fundamental change suggested by table 1 and figure 1 is that the role of exports in the aggregate has strengthened.[2] The domestic share has declined because over time the income elasticity for these crops in the United States has fallen because of high per capita incomes. Thus, current growth in U.S. domestic demand for most crops is largely due to population increases rather than to income changes (*4*).

The data presented in table 1 do disguise one change which is truly fundamental to understanding the present international environment facing U.S. agriculture. During the 1909-12 period, the export market for U.S. agricultural commodities was in Western Europe. When that market collapsed after World War I, U.S. agriculture collapsed as well. In 1909-12, 83 percent of U.S. exports went to Europe (excluding Russia), of which most was for the United Kingdom (*20*). Seventy years later, only 28 percent went to Western Europe, whereas 13 percent went to centrally planned nations and 36 percent went to developing nations (*19*). The shift in world trade patterns from Europe and toward centrally planned and developing nations represents a fundamental change. These nations' demand for food tends to be more income elastic than does Western Europe's; hence, developing nations' imports are more sensitive to changes in consumer expenditures. Most of these nations have borrowed heavily in international financial markets to finance imports. Their ability to sustain large food imports is now suspect as debt-servicing problems mount. These nations tend to rely on state trading institutions or more rigid import restrictions rather than on private markets. Thus, the institutional structure of the market has changed as trade patterns have shifted.

Variability in U.S. agricultural prices due to the integration in world markets is a problem currently facing U.S. agriculture. Except for the middle of this century, variability has always been an issue (*3*). In the early 19th century, increases in export demand for cotton raised prices and stimulated a western migration of the U.S. cotton industry (*12*). When supply increases outstripped demand, prices fell, land sales slowed, and producers switched to other crops. Such cycles have been frequent for cotton and other crops throughout the 19th and 20th centuries. A similar cycle began in 1972. High commodity prices and an expansionary monetary policy stimulated production and raised land values. Supply has recently outstripped demand, and commodity and land prices have fallen dramatically.

Table 2 shows the average percentage of year-to-year variations in U.S. season-average prices by decade since 1870, revealing a U-shaped pattern as with table 1. Prior to the thirties, prices were unstable. For wheat, the average percentage change in prices varied from a high of 26 percent in 1920-29 to a low of 13 percent in 1900-19. Corn prices also varied greatly, but did not have the range of variability which wheat prices had, from a low of 15.6 percent to a high of 22.6 percent. The average percentage changes in prices of cotton and tobacco were quite erratic prior to 1930, with lows of 5 percent and 6 percent and highs of 24.9 percent and 20.6 percent, respectively.

[2]Weighting the proportion of each crop exported by its contribution to total production shows that corn dominates. Because exports are increasingly important to corn producers, the aggregate role of trade for U.S. crop producers has become increasingly more important.

Table 2—Average year-to-year changes in season-average prices received by U.S. farmers for selected crops, by decade, 1870-1979[1]

Decade	Wheat	Corn	Cotton	Tobacco	Rice
			Percent		
1870-79	13.64	20.20	13.34[2]	22.43	—
1880-89	20.60	22.56	5.14	15.70	—
1890-99	15.51	18.30	19.86	13.64	—
1900-09	13.06	19.29	19.26	6.13	—
1910-19	13.07	15.60	24.86	20.65	19.69
1920-29	26.05	17.63	18.01	10.34	13.20
1930-39	24.45	36.94	20.95	23.15	19.60
1940-49	14.90	23.16	12.81	10.73	16.84
1950-59	3.60	6.32	6.20	3.27	8.25
1960-69	11.76	6.17	9.99	4.01	2.00
1970-79	23.84	19.50	16.99	8.56	27.92

— = Not available.
[1]Calculated by averaging the absolute year-to-year price changes and dividing by the mean price for the decade.
[2]Data for 1876-79 only.
Source: (*18*).

During the thirties, year-to-year price changes were large—for corn the largest of the entire series and for wheat the second largest—because of large declines in crop prices during the Depression. In the fifties and sixties, the variation in prices for all commodities declined sharply. In the seventies, price variability resembled that of the twenties and thirties. The year-to-year price variability for wheat rose to 23.8 percent, just slightly above the "normal" level prior to 1930, but well within the overall historical range. The year-to-year changes for corn and cotton prices are consistent with the pre-1930 level, although the price of tobacco varied less. Only rice prices varied considerably above the pre-1930 level.

Although price variability itself is not new, the data in table 2 show that it has increased for all crops since the fifties and sixties. A major factor has been increased world agricultural trade barriers as well as changed policy instruments used for protection purposes. The growing importance of developing and centrally planned nations as markets for agricultural products has increased price variability. Most of these countries are state traders or they use other policies which sever the link between domestic and world prices (*1, 22*). An abrupt change in policy, such as the Soviet decision to import grain rather than slaughter livestock in 1972, can cause tremendous price changes in a world market where trade barriers allow relatively little adjustment to world price movements.

Although West European nations account for a declining share of world agricultural trade, particularly for wheat, they are still important factors in the market. At the outset of this century, the European nations primarily used tariffs to protect their agricultural producers (*11*). Tariffs permit price variations to move across borders (*1*). These nations have adopted policies in recent years which insulate their domestic markets from world price changes, thereby magnifying the instability in world prices.

Britain is a particularly useful example of such policy changes. In the early 20th century, Britain was a large wheat importer and followed a free trade policy. During the thirties, Britain adopted import tariffs as did all other countries (*11*). In 1973, Britain joined the EC and accepted the EC policy of variable levies which add to world price instability. Other European nations followed a similar path, although at different speeds. Current policies in Western Europe magnify the instability in world prices.

Institutional developments in other exporting countries may have also increased world price variability. The Canadian Wheat Board is a product of the Depression and acts to stabilize producer returns. The Australian Wheat Board is an outgrowth of World War II (*2*). Stochastic simulation analysis of board marketing suggests that these types of institutions can also increase world price variability (*14*).

Macroeconomics and U.S. Agriculture

Another recurring theme in the current literature is that U.S. agriculture is increasingly integrated into the U.S. and global macroeconomy. Except for the middle of this century, U.S. agriculture has been integrated into the rest of the economy. In the late 19th century, farmers' concerns focused on railroad shipping charges, credit, tariffs, and the U.S. currency. The populist platform of July 1892 advocated the free coinage of silver and a graduated income tax (*7*, p. 525). Other political demands by

farmers included reduced tariffs on industrial goods and reduced interest rates, from 10 percent to 8 percent (*3*, pp. 120-22). The "boom and bust" cycles of the 19th and 20th centuries were heavily influenced by changes in the money supply. A policy to inflate the economy to benefit agriculture even helped launch William Jennings Bryan's 1896 presidential campaign. Agriculture versus protection debates are not a recent phenomenon. Conflicts between farmers seeking export markets and manufacturers seeking import relief were a major theme of U.S. history in the 19th century.

These same problems are faced today. The 1984 *Economic Report of the President,* for example, discusses the sensitivity of agriculture to changes in interest rates and monetary policy (*6*). According to *The Washington Post,* farmer representatives and labor leaders have exchanged sharp debate in hearings over auto-content legislation and restrictions on steel imports (*21*). U.S.-Chinese agricultural trade has been disrupted by disputes over protection of U.S. textile manufacturers.

If macroeconomic factors are not new to U.S. agriculture, why is it popular to write that they are? The statement that U.S. agriculture is increasingly integrated into the rest of the economy partly reflects an exceptional period for U.S. agriculture and partly reflects changes in the magnitude of interaction.

Although 19th century growth in U.S. agriculture and railroads was heavily financed by eastern U.S. and British banks and although farmers then purchased their inputs from the nonfarm sector and relied on credit, agriculture now depends even more on the rest of the economy than in the past. Table 3 shows the share of production costs and the share of interest on farm mortgage debt in U.S. gross farm income by decade since 1910. Both have the familiar U shape. In the 1910-19 period, 3.1 percent of farm income went to interest on farm mortgage debt. Declines in farm income during the twenties and thirties increased the share to almost 5 percent. By the forties, the interest share had fallen to 1 percent, perhaps a reaction to the use of debt financing by those farmers who survived the Depression. Interest as a share of gross receipts began to rise in the sixties and was only slightly greater in the seventies than in the 1910-19 period.

Table 3—Shares of interest on farm mortgage debt and production expenses in U.S. gross farm income, by decade, 1910-79

Decade	Share of farm income	
	Interest[1]	Production expenses[2]
	Percent	
1910-19	3.1	48.9
1920-29	4.8	57.7
1930-39	4.6	58.6
1940-49	1.0	50.8
1950-59	1.1	64.3
1960-69	2.3	69.4
1970-79	3.5	69.0

[1]Interest on farm mortgage debt divided by gross farm income.
[2]Total production expenses divided by gross farm income, including feed purchased, livestock purchased, seed purchased, fertilizer and lime, repairs, depreciation, hired labor, taxes on farm property, interest on farm mortgage debt, and rent to landlord.
Source: (*18*).

The share of farm income going to all production expenses tells a slightly different story. Prior to the Depression, inputs purchased accounted for between 48.9 and 58.6 percent of gross farm income. During the fifties, sixties, and seventies, the inputs' share of farm income rose to 64.3 percent, 69.4 percent, and 69 percent, respectively (table 3). One major development was that after World War II, U.S. agriculture increased its reliance on purchased fertilizer, seed, and fuel.

Flexible exchange rates and international asset markets represent other factors which may have reemerged in a different form. With the currency-flow system, international currency transfers, in principle, served to expand or to contract the monetary base, thereby causing internal price adjustments to external disequilibrium. With the end of the Bretton Woods Agreement in the early seventies, exchange rate movements caused internal prices to adjust to external disequilbrium unless other policies were used to prevent this adjustment. Schuh argues that the emergence of world financial asset markets in the context of flexible exchange rates is a fundamental change (*17*). Whether this situation represents a change can be debated. European and U.S. asset markets were well integrated in the 19th century as extensive foreign (mostly European) financing of U.S. agricultural development showed. Given the importance of Europe to

U.S. exports in the early 20th century, the export market and financial asset market may have been as completely integrated then as it is now.

World trade patterns have fundamentally changed as developing and centrally planned countries have increased their importance to world agricultural trade. World financial asset markets have expanded to meet this change. The ability of these nations to finance imports of agricultural products, or to increase expenditures in relation to income, is a critical development. The pool of loanable funds worldwide expanded rapidly after the oil price rises in 1973 and 1979. The use of monetary policies to accommodate these price shocks, especially after 1973, allowed financial assets to flow from developed countries to oil exporters, who then (through commercial banks) provided credit to developing and centrally planned nations. The rapid growth in demand for U.S. agricultural exports in the late seventies was partly due to growth in exports to developing and centrally planned countries resulting from these financial transfers. U.S. agricultural exports slowed in the early eighties because these nations were unable to service their debts which had accrued as a result of these transfers. A major difference with the past is that the loans of the late seventies were made to national governments rather than to individuals. As a result, bank solvency and in some cases the solvency of the world financial system depend on a single debtor's ability and willingness to repay obligations.

Reemergence of the International Environment

The changes in the international trade environment facing U.S. agriculture represent a reemergence of the old environment with a somewhat greater influence on U.S. agriculture. Why did the old environment reappear? Changes in U.S. commodity policies and in U.S. macroeconomic policy appear to be strongly linked with this reemergence.

The U-shaped patterns observed earlier reflect changes in these factors. The data can be divided into four phases based on U.S. Government policy. The first phase was one of limited direct U.S. Government involvement in both agricultural commodity markets and the macroeconomy; that phase ended about 1930. Prior to that time, the direct involvement of the Federal Government in agricultural commodity markets was limited. The Homestead Act, the Morrill Land Grant Act, and the establishment of the U.S. Department of Agriculture and the Extension Service were aimed primarily at improved production and land availability rather than at price support. The Federal Land Bank system, established in 1916, provided long-term credit, while Federal Intermediate Credit Banks were established in 1923 (*4*). These policies were forms of production subsidies. The Agricultural Marketing Act of 1929 created the short-lived Federal Farm Board, but not until 1933 did the U.S. Government become directly involved on a large scale in agricultural commodity markets.

The story of U.S. Government involvement in the macroeconomy prior to the thirties was similar to that for agriculture. The years after the Civil War saw improvements in banking, promotion of the development of commercial infrastructure, regulation of industry, and enactment of various tariff policies. But, policies designed to stimulate aggregate demand were years away. Even Franklin D. Roosevelt promised to balance the Federal Budget in 1932. The U.S. Government nominally had limited control of monetary policy. However, J.P. Morgan controlled gold reserves rivaling the U.S. Treasury and allegedly averted a monetary collapse in 1907 (*5*). The Federal Reserve System, created in 1913, was inexperienced, as subsequent events during the Depression would show.

The 1930-70 period sharply contrasts with the experience of agriculture throughout most of the rest of U.S. history. The Federal Government's response to the Depression and its aftermath has been well documented—both for agriculture and the general economy (*4, 13, 16*). The Federal Government set price supports for agricultural commodities above market-clearing levels, established marketing orders, took land out of production after World War II, and accumulated stocks throughout the fifties and sixties. Exports were subsidized or sold to needy countries on concessional terms to offset the loss of competitiveness due to the price supports. Fiscal policy evolved in an era of aggregate demand management, while monetary policy targeted interest rates—all under a system of fixed exchange rates.

One of the consequences of this policy environment was that price variability in agriculture in the fifties and sixties was low in relation to previous decades because prices were supported at U.S. Government-determined levels (table 2). A Government market replaced the export market. Support prices above world market levels reduced foreign import demand and encouraged export supply by our major competitors, thereby reducing the role of U.S. exports (table 1). Public stocks and Federal expenditures for agriculture mounted. Export subsidies and credit programs in the fifties and sixties offset the effects of price supports on world markets and reduced Federal expenditures by reducing public stocks (*10*). Interest rate targeting and mildly expansionary fiscal policy created inflationary pressures in the early fifties, late sixties, and early seventies, and produced low and stable interest rates which lessened the debt load of U.S. farmers (table 3). These circumstances worked in conjunction with agricultural policy to stimulate farm output. An increasingly overvalued fixed exchange rate added an implicit tax on exports.

During this period the problems of price variability, a large reliance on trade, and the linkages between U.S. agriculture and the world macroeconomy were masked by a Government-regulated agriculture and by policies designed to manage aggregate demand. As the agricultural imbalances created by this policy mix became apparent, real support prices for wheat, corn, and rice began to drop about 1950 (figs. 2, 3, 4). For cotton, the process of lowering real support prices started later and proceeded more slowly than for grains. U.S. agricultural policy entered a phase of a reduced Government role in supporting commodity prices through the sixties and into the seventies. Target prices and deficiency payments designed to protect farm income without circumventing market price signals became the mainstay of U.S. commodity programs in the seventies. For wheat and feed grains, the process of Government transition from farm price support to income support proceeded quickly, and the relationship of trade to these commodities and the problem of price variability reemerged (tables 1 and 2). For cotton and tobacco, the transitional role of the U.S.

Figure 2

Real Support Prices for Corn and Wheat

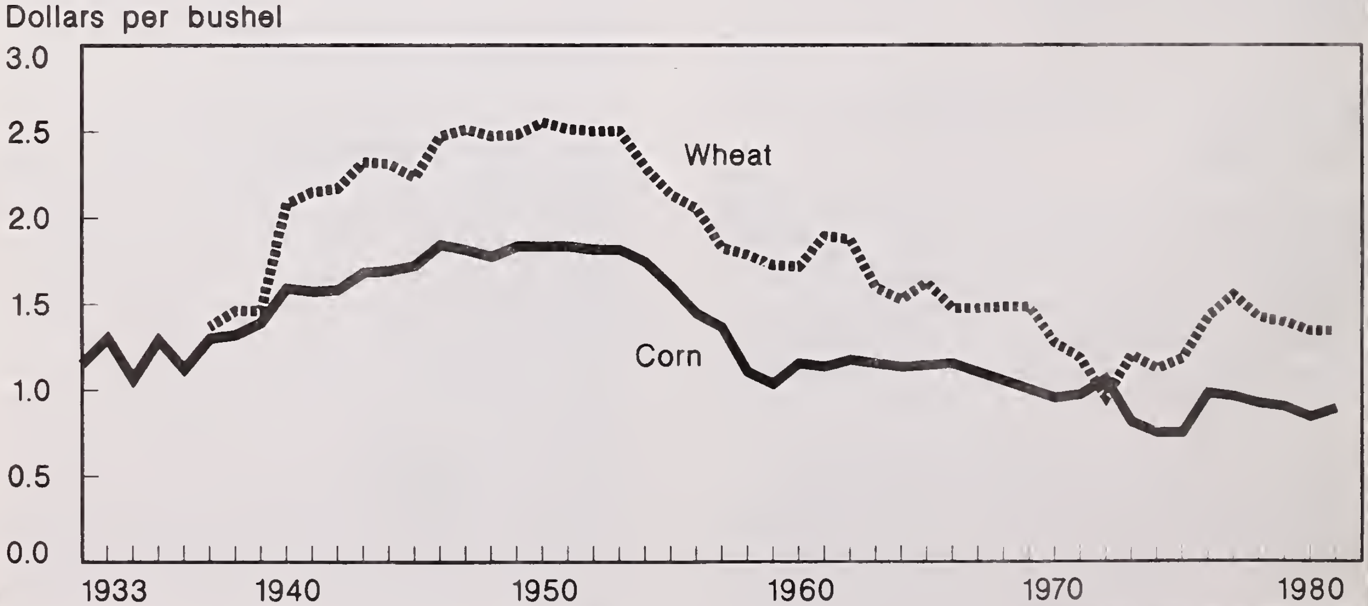


Figure 3
Real Support Prices for Rice

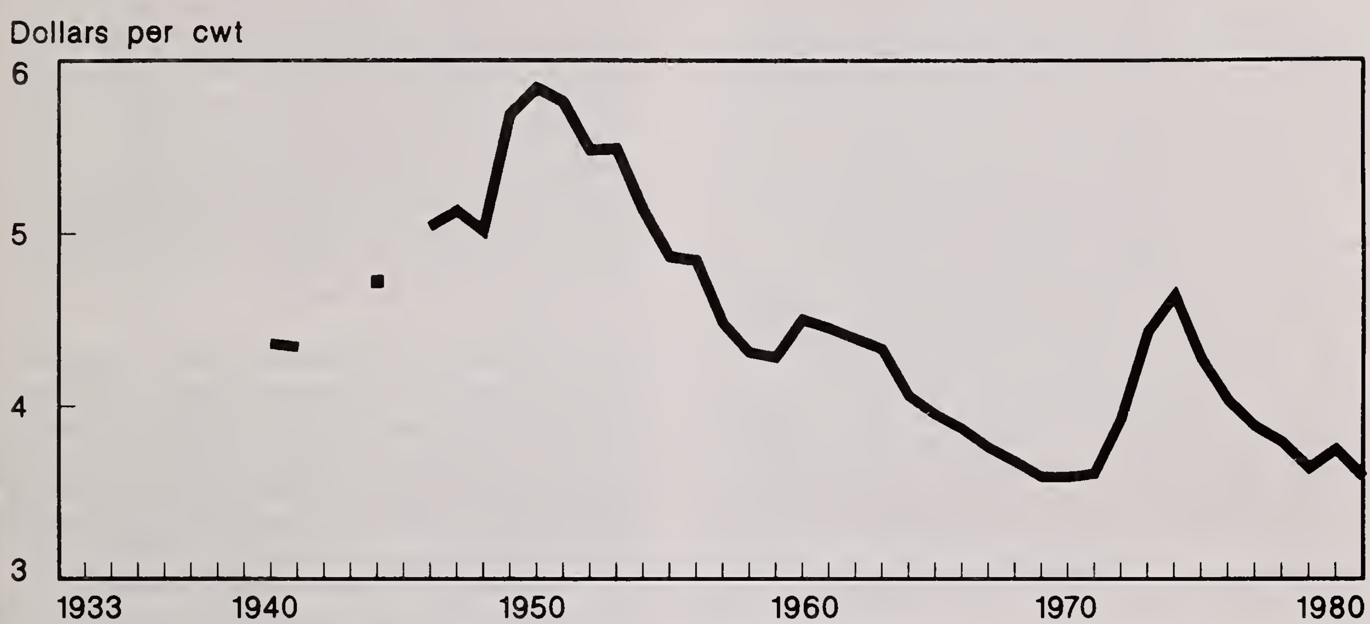
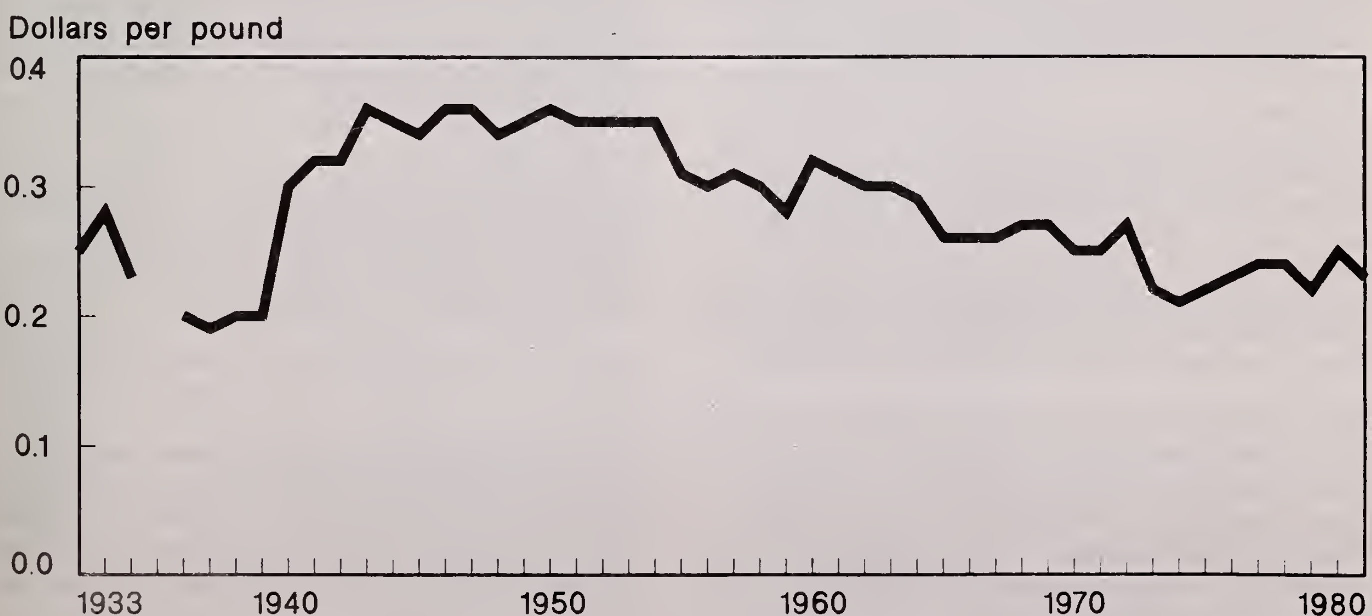


Figure 4
Real Support Prices for Cotton



Government was slower and less complete. Thus, trade has not recovered its traditional importance for these crops, and price variability is less of a problem (tables 1 and 2).

By the early seventies, the imbalances from U.S. macroeconomic policy also became evident. Rapid expansion of the money supply and world liquidity following the oil price increases reduced real interest rates and caused developing nations to borrow funds on international financial markets to finance imports and economic growth. Monetary policy became more erratic as well, first being tightened and then loosened in succession throughout the decade (*6*, p. 291). These changes in money supply growth, in conjunction with the target price policy, increased the variability in commodity prices. Fixed exchange rates were replaced by flexible rates which were sensitive to macroeconomic shocks, adding another dimension of variability to commodity prices. Fiscal policy seemed less effective and more in conflict with monetary policy as Federal expenditures grew in relation to tax receipts. Both unemployment and price levels rose simultaneously.

The policy environment appears to have changed again in the early eighties. In 1979, the Federal Reserve switched from a policy of targeting interest rates to one of targeting the growth of the money supply. The objective of the change was to reduce inflation by maintaining tighter control of the growth in the money supply. Inflation has declined sharply, but at the expense of an increase in both nominal and real U.S. interest rates. Despite a Federal Reserve policy of steady monetary growth, fiscal policy has been expansionary. In the early eighties, the supply-side economists advocated and obtained tax cuts to restore incentives for investment. These achievements have stimulated output and employment, but they have also led to a burgeoning Federal budget deficit. The Federal Government's demand for loanable funds has been a major factor in sustaining high real U.S. interest rates.

These macroeconomic policies have affected U.S. agriculture in two ways. First, the rise in U.S. interest rates has attracted foreign capital, raising interest rates abroad. One result was a global recession in the early eighties. Second, the influx of foreign capital has caused the dollar to appreciate rapidly. Developing and centrally planned nations, who had borrowed heavily at low real rates of interest on short-term credit markets in dollar-denominated accounts, have become vulnerable to both increased interest rates and the stronger dollar. Hence, the major growth markets for U.S. agriculture in the seventies faced severe economic difficulties. In addition to a slowdown in the growth rate of the world market, the stronger dollar has reduced the competitiveness of U.S. exports in relation to those of other exporting countries. Agriculture has been especially affected because price-support programs have prevented the downward adjustment of U.S. prices which would allow agricultural commodities to compete.

On the domestic front, agriculture, as a major user of borrowed capital, has been squeezed by high real interest rates and declining world prices for its products. This situation has led to the worst financial crisis since the thirties. At the same time, deepening public concern about the size and growth of the Federal deficit has led to attempts to reduce Federal budget expenditures, including those on programs like agricultural commodity programs.

The current conflict between U.S. monetary and fiscal policies cannot be sustained in the long run. Growing pressure in Congress to reduce the Federal deficit is a recognition of this fact. Yet, the measures required to bring the budget into balance become increasingly more difficult to implement as increases in the debt load takes an ever-growing share of Federal expenditures. The experience is unprecedented in U.S. history.

Macroeconomic policy appears to be on the verge of a major transition. The character of this transition, however, is uncertain because it will be shaped largely by responses to future events. These changes will have significant effects on trade and agriculture.

These macroeconomic factors, increased world production due to good weather, and adoption of new technologies overseas have decreased U.S. exports and farm prices, deteriorating U.S. net farm income. Loan rates, which in the seventies were rarely effective in supporting prices, again supported the market; as in the fifties and sixties, these price supports implicitly taxed U.S. exports, thereby providing incentives to foreign producers (*15*). The U.S. Govern-

ment responded by returning to previously used policies, such as the Acreage Reduction Program of 1982 and the Payment-in-Kind program of 1983.

These programs suggest a greater Federal role in U.S. agricultural commodity markets. Such a role is tremendously expensive and is not likely to last without a dramatic change in how these programs are structured, funded, and operated. Thus, U.S. agricultural policy is also in a state of transition as Government officials grope for an effective means to deal with this environment.

Conclusions

The changes in U.S. agricultural and macroeconomic policy in the past two decades have allowed an international environment which the United States once faced to reemerge. Exports are again critical to the health of the agricultural sector. Variability in commodity prices, farm income, and land prices due to uncertain export demand has returned. Fluctuating exchange rates and interest rates add to the volatility of prices and input costs. Income growth both at home and abroad is again critical to U.S. agriculture.

Some aspects of the international environment are different after the passage of the intervening decades. The composition of U.S. agricultural exports has changed in favor of ingredients for livestock feed—namely, corn and soybeans. Some buyers and sellers and the institutions in which they operate are different now. Developing countries and centrally planned nations have replaced Western Europe in importance in trade. Many centrally planned countries are erratic buyers. Imports by developing countries depend on international credit and income growth. Even the institutions used by European nations have changed so that they add to price variability. Most of these differences, however, amplify rather than change the roles of trade and price instability.

The critical question faced by U.S. agricultural officials is how future U.S. agricultural and macroeconomic policy will evolve. Will the United States respond to the reemerged international environment by returning to a policy of intervening directly in commodity markets so as to isolate the agricultural sector from trade and variability and from other sectors? Or, will the United States adopt a policy somewhat like that of the 19th century and the first 30 years of this century, when U.S. policy attempted to provide farm income support without direct intervention in commodity markets? What alternative policies might be adopted to deal with U.S. agriculture in an international context? The answers to these questions will depend largely on changes now taking place in the macroeconomic and trade environment facing U.S. agriculture. When future policy strategies are analyzed, the lessons (both positive and negative) learned by earlier generations of officials and farmers can help us understand in what sense current problems facing agriculture resemble those in the past and in what sense they are unique. This knowledge can provide valuable insights into the formulation of future farm policies.

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Research Review

Sources of International Comparative Advantage: Theory and Evidence

Edward E. Leamer. Cambridge, MA: MIT Press, 1984, 353 pp., $45.00

Reviewed by Stephen W. Hiemstra*

For those willing to accept the challenge, Edward Leamer's *Sources of International Comparative Advantage: Theory and Evidence* is an excellent text. Leamer lays out the theoretical and statistical issues confronted in validating Ricardo's law of comparative advantage[1] and exhaustively reviews resource and trade data. In pursuit of a more perfect understanding of the Heckscher-Olin (H-O) theorem, however, the reader is burdened in the final chapters with weighing the effect of numerous theoretical and statistical assumptions on the author's conclusions. Leamer's contribution accordingly lies with the thorough theoretical and methodological discussions in the earlier chapters.

Leamer begins with the Heckscher-Olin-Vanek (H-O-V) theorem: a country with balanced trade will export services of abundant factors and import services of scarce factors. The H-O-V theorem assumes that factors of production are immobile between countries and hypothesizes that they are used in different combinations to produce a range of goods. Net exports are then defined mathematically as a linear function of an inverse matrix of factor intensities times a vector of excess factor supplies (that is, a relationship among three measurable quantities: trade, factor intensities, and factor abundance). In his statistical model, Leamer postulates a linear relationship between two of these quantities: trade and factor abundance.[2] In estimating this model, he employs quantity, net-export data aggregated at the two-digit level (that is, 10 categories of products) and data on 11 resources for 60 countries.[3]

Most of the book is devoted to Leamer's methods. Chapter 1 reviews the assumptions of the H-O-V theorem:

(1) The number of goods equals the number of resources;
(2) Factors are mobile within countries, but are competitive among countries;
(3) Factor and product markets are competitive;
(4) Perfect knowledge, constant returns to scale, and diminishing marginal productivity exist;
(5) Factor prices are equalized among countries; and
(6) Individuals facing identical product prices consume products in the same proportions.

This inquiry specifies the mathematical model and explores deviations from its assumptions. Leamer's critical deviations include the following:

(1) When the number of resources and products are unequal, the outcome of trade is indeterminant;
(2) When factor prices are unequal among countries, no unique correspondence between resources and products is assured; and
(3) When returns to scale are not constant, trade need not lead to factor price equalization, markets need not be competitive, and the model may violate other assumptions of the H-O-V theorem.

Of these three deviations, Leamer views economies of scale as most likely to affect the pattern of trade significantly.

Leamer discusses several interesting observations in chapter 1. First, at constant output prices, an increase in the supply of a factor will increase the output of the commodity which uses that factor intensively and will reduce the output of the other commodity (the Rybczynski theorem). Second, an increase in the price of the imported good will increase the return to the scarce factor and will reduce the return to the abundant factor (the Stolper-Samuelson theorem). Third, if the number of resources and products are unequal, small transport

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[1]David Ricardo, *The Principle of Political Economy and Taxation* (New York: Dutton, Everyman's Library, 1976), pp. 77-93.

[2]In leaving the inverse matrix of factor intensities (that is, shadow prices) out of his empirical model, Leamer tests for absolute rather than comparative advantage.

[3]The products are classified according to the Standard International Trade Classification (SITC) code. The resources include: capital, three classes of labor, four classes of land, coal, minerals, and oil.

costs may determine the composition of trade. Fourth, tariffs must be greater than transport costs to affect the pattern of trade. Fifth, nontraded goods do not materially affect the assumptions of the H-O-V theorem.

Chapter 2 outlines Leamer's methodology. He builds his critique on two points: (1) the law of comparative advantage in the n-good case is imprecisely stated in theory and empirical tests, and (2) alternative trade theories have not yet been effectively articulated. In his first point, Leamer observes that analysis of comparative advantage seldom extends beyond the two-goods case. Furthermore, Leamer explains the Leontief paradox as a misspecified condition for substantiating relative factor abundance.[4]

In his second point, Leamer calls for articulation of alternative trade theories. Rather than evaluate comparative advantage as an abstraction, Leamer, the statistician, prefers to compare it with an alternative hypothesis such as: "The H-O model serves as a more accurate guide for trade policy than the scale economy model" (p. 47). In spite of his concern, Leamer likewise does not test an alternative hypothesis.

Chapters 3 and 4 review the resource and trade data employed in later estimations. Leamer graphs important relationships, tests resource and trade aggregates for statistical properties, and examines export commodity clusters. Export clusters are product groups produced that use similar resources. Export clusters pose a problem because theory suggests that countries will specialize in producing commodities, not clusters of commodities. These clusters may emerge because production externalities exist, diversification reduces market risk, and few countries possess the resources needed to produce the commodities of a given cluster (pp. 78-83). Leamer views the distribution of resources as the most credible and theoretically sound explanation for clustering.

In chapter 5, Leamer states that, for purposes of estimation, the objective "is to 'predict' a randomly selected country's net exports or Gross National Product (GNP) given its endowments" (p. 153). These four assumptions apply:

(1) Errors terms are normal, randomly distributed variables with zero means and constant, unknown variance;
(2) Measurement errors are unimportant;
(3) A linear relationship between resources and products exists; and
(4) The data are adequate for prediction (p. 117).

Based on his review of the data, Leamer hypothesizes that the estimation is complicated by systematic heteroskedasticity, gross measurement errors, and nonlinearities. Furthermore, the estimated relationships are collinear enough so that the structural relationships are also probably collinear. Perhaps for this reason, Leamer uses beta variables in place of t-statistics in selecting variables for his empirical model.

In chapter 6, Leamer summarizes his econometric strategy with these words:

> . . . The approach that will be taken is first to estimate the model using ordinary least-squares methods. Second, these estimates are corrected for systematic heteroskedasticity that is assumed to be a function of GNP. Third, the sensitivity of the heteroskedasticity-adjusted estimates to the deletion of observations is studied to detect gross errors. Fourth, the sensitivity of the ordinary-least-squares regression to chronic measurement errors is explored.[5] Fifth, a Bayesian analysis of the homoskedastic model is performed, including a study of the fragility of the Bayes estimates.[6] Last, nonlinear functional forms are tested.

Leamer answers the following questions with his model:

(1) How well do the 11 measured resources explain trade?

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[4]Leontief compared the capital/labor ratios of imports with exports when he should have compared the U.S. share of world capital and labor supplies in determining relative resource abundance, according to Leamer (pp. 52-53).

[5]In chapter 5, the omission of key observations from the data set significantly affects some variables.

[6]Leamer expends considerable effort in chapter 5 analyzing restrictions on use of prior information and providing examples of their use. These details may interest theoretical econometricians, but they go beyond the scope of this review (pp. 136-54).

(2) Do the coefficients take on surprising values?
(3) Has the structural relation between trade and endowments changed over time?
(4) Which are the most important resources? and
(5) What effect do tariff structures have on the functional distribution of income?

Leamer, unfortunately, does not use these questions to structure the discussion of his results. Instead, he provides running commentary, table by table, of his results. In view of the procedure's complexity, this style of presentation makes evaluating his results difficult. One is left to ponder the relative credibility of the reported observations.[7]

Nevertheless, Leamer answers these questions in chapters 6 and 7. In the context of his work, resources explain trade to the extent that a linear relationship exists between resources and products. Leamer tests for nonlinear relationships and concludes: "this form of nonlinearity does not cause large changes in the interferences, but it does cause substantial changes in labor productivities" (p. 182). This conclusion is supported by cited observations substantiating factor price equalization.[8]

Several coefficients in Leamer's equations do take on surprising values and make surprising shifts. The coefficient for highly skilled labor has the largest beta coefficient, followed by capital, skilled labor, and oil. Highly skilled labor's importance in trade in manufactures declines relative to capital between 1958 and 1975. Another shift for manufactured goods occurred during this period as coal lost significance relative to oil as a source of comparative advantage. Furthermore, capital was a source of comparative advantage and highly skilled labor was a disadvantage[9] in cereal grain exports in 1958; these observations were reversed in 1975.[10] Land resources contributed to comparative advantage in cereal exports in both years, as we might expect.[11]

Leamer reports that skilled labor and capital were the most important resources in 1958 and 1975, respectively, in determining the composition of U.S. exports. He reported that the United States was scarce in capital, skilled and semi-skilled labor, land, minerals, and oil in 1958 and abundant in highly skilled labor and coal. By 1975, capital and the first three classes of land had become abundant.[12]

Leamer assesses the effect of changes in resource endowments and tariffs on trade in chapter 7, but his discussion is hard to follow for lack of clear summary statements.[13] Leamer reminds us that his model is a longrun model of trade; the shortrun motivation of participants and outcomes could be quite different. Beyond this observation, however, the overall implications of Leamer's counterfactual tests are neglected in favor of a continued discussion of model specificiations and mechanics. The concluding pages do not summarize the final chapter, and the few observations cited and discussed provide an almost anecdotal image of his work. Chapter 6 does a better job of summarizing Leamer's results, albeit incompletely.

In spite of a weak ending, Leamer's book adequately covers the theoretical and statistical problems inherent in testing the H-O-V theorem and provides a lengthy bibliography of pertinent literature. Although technically complex, the first five chapters of the book are more readible than most texts of this genre. In view of its complexity and expensive price, however, its appeal is limited to analysts interested in international trade theory and econometrics.

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[7]The author recognizes this problem. In the text he provides disclaimers, such as: "Because of the seriousness of chronic measurement errors, the estimates in this table need not be treated too seriously" (p. 162).

[8]Anne O. Krueger, "Factor Endowments and Per Capita Differences Among Countries," *Economic Journal,* Sept. 1968, pp. 641-59.

[9]Although this result appears credulous at the outset, it is consistent with the Stolper-Samuelson theorem cited earlier.

[10]One has to wonder whether 1975 data might not pose special problems when the H-O-V theorem is tested because of the disequilibrium created in world markets by the oil embargo and world grain shortages of 1973.

[11]In this analysis, the ranking of resources as sources of comparative advantage seems more credible than the magnitude of their contribution in such trade projections (p. 200).

[12]These shifts in resource scarcities add credence to the analysis. In a market economy undergoing technological and institutional change, changes in the relative value of resources are expected—in spite of perfect resource immobility—as an inevitable consequence of economic development. For example, see Albert O. Hirschman's *The Strategy of Economic Development* (New York: W.W. Norton & Company, 1958; The Norton Library, 1978).

[13]This comment applies both to organization and content. At one point in the discussion (p. 191), Leamer presents a table of values for discussion generated from an "optimally selected reallocation of resources." Both the selection process and the precise allocation of resources are unexplained. This lack of explanation seems unusual in a text which earlier provided lengthy discussions of theoretical and statistical techniques.

Made in Washington: Food Policy and the Political Expedient

Clarence D. Palmby. Danville, IL: The Interstate Printers & Publishers, Inc., 1985, 226 pp., $14.95.

Reviewed by Martin E. Abel*

Clarence Palmby observed first hand over nearly 50 years the evolution of U.S. agriculture and agricultural policy in various capacities—as farmer, Government official, market developer, and business executive. Those concerned with U.S. agriculture will benefit from Palmby's insights and experience.

The tone of his book is set in the first sentence: "Prices are made in Washington." Palmby clearly believes that the Government has interfered in U.S. agriculture too much through restricting output and supporting commodity prices. These interventions compounded the surplus problems of the fifties, sixties, and early eighties by encouraging production and discouraging exports and domestic use. They restricted the market place from bringing about necessary adjustments in supply and consumption.

The author, however, is not against any and all interventions in agriculture. He favors:

- Low levels of price supports that do not interfere with the market most of the time but that do provide protection against precipitous price declines,
- International trade liberalization, and
- Market development activities that increase total demand for U.S. agricultural exports longer term.

In short, Palmby is for demand expansion and against controlling supplies.

Some of Palmby's reflections also deal with the political and administrative processes that make U.S. farm policy. He worked in these arenas for several years and thus can speak knowledgeably about what it takes to be effective. He is a realist, recognizing that honest men and women can hold different views and that these differences should be respected. One needs to be patient, yet persistent, in changing policies; sooner or later the power of events will force Government to adjust to reality.

Made in Washington is timely in view of the recent efforts to forge a new farm bill which moves in a direction advocated by Palmby—more reliance on the market and more emphasis on increasing demand. Yet, one senses that policy changes are being driven largely by the current depressed situation in agriculture rather than by long-term considerations. The danger in this situation is that people develop unrealistic short-term expectations and ignore the long-term problem of how once again to achieve demand growth worldwide. Those involved in the policy process could benefit from Palmby's reflections, for they would realize that policy changes do not necessarily yield instant success. It may instead take years before correct policies bear significant fruit.

The book has a number of shortcomings. First, the author assumes the reader knows a lot. Those unfamiliar with the history and technical details of agricultural policies and programs will have a hard time following some sections of the book. Second, Palmby's material is not always well organized, which unnecessarily interrupts the flow of his arguments. Finally, some of the history is incomplete. For example, Palmby extensively discusses the bad features of the 1983 payment-in-kind program which sharply reduced output and raised prices at a time when the United States was losing its competitive position in world markets. He makes no mention, however, of the 1982 farmer-owned reserve program that encouraged farmers to produce and store grain and that artificially supported prices when production should have actually been discouraged and prices been allowed to fall.

Despite these shortcomings, Palmby has written an interesting memoir that is worth reading. One should not ignore hard-earned experience.

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The Handbook of Econometrics

Volume 2. Zvi Griliches and Michael D. Intrilligator (eds.). Amsterdam: Elsevier Science Publishers, 1984, 585 pp., $65.00.

Reviewed by David Freshwater*

Reviewing a book written by a number of authors is an onerous task; reviewing one volume of a series by numerous authors is even more difficult. However, when the series is entitled *The Handbook of Econometrics,* the task is nearly insurmountable. Volume 2 of the handbook contains three parts of unequal length: "Testing," "Time Series Topics," and "Special Topics In Econometrics." The section on "Time Series" comprises the bulk of the volume, having six chapters, while the section on "Testing" has four and the "Topics" section two.

The detailed nature and diversity of the various chapters prohibits comprehensive review of the subject matter in each chapter. Instead, I have decided to evaluate the book from the perspective of what I would call a sophisticated regression runner—that is, an individual with an empirical orientation, but one who has been exposed to a good course in graduate econometrics and has a working knowledge of linear algebra and mathematical statistics. The vast bulk of agricultural economists who might consider consulting a series of volumes with the portentous title, *The Handbook of Econometrics,* would presumably fall into this class.

The editors set themselves the task of creating three volumes which are ". . . to serve as a source, reference, and teaching supplement for the field of econometrics, the branch of economics concerned with empirical estimation of economic relationships." The focus of the handbook is clearly on the theory of econometrics and not on empirical estimation. This volume presents recent advances in the development of tests of hypotheses, the use of time series models, and the appropriate use of latent and qualitative variables. The material should provide "comprehensive and accessible surveys" to professionals and advanced graduate students. The editors' intent is surely not to create a cookbook of recipes for the neophyte.

Have they met their goal for my sophisticated regression runner? Unfortunately, they have not. Unlike several other handbooks in this series, this volume is not a self-contained book of instructions that would meet the needs of the audience I have defined. The book fails on several grounds. The level of mathematical sophistication generally exceeds that of most applications-oriented agricultural economists. The presentation neither motivates the reader in the sense of setting out critical points nor follows a well-structured path linking individual issues in the various chapters. The three sections could have been improved by a brief introductory comment identifying the objectives and showing how they relate. As currently constituted, the book reads more like a collection of journal articles than a guide or source of information for individuals with limited knowledge of specific topics. Conversely, the advanced econometrician with a strong background and familiarity with econometric and statistics journals is likely to find the handbook a redundant source as it provides little new material.

Of the individual papers, those by Granger and Watson on "Time Series and Spectral Methods in Econometrics," Chamberlain on "Panel Data," Aigner, Hsiao, Kapteyn, and Wansbeck on "Latent Variable Models," and McFadden on "Econometric Analysis of Qualitative Response Models" are the most clearly written, providing the reader with a clear outline of the topic at a level within the grasp of the target audience. These chapters mix verbal and mathematical exposition, enabling the reader to get over the harder spots.

Other chapters emphasize proofs almost to the exclusion of applications, examples, and verbal description. Individuals unfamiliar with the topics would likely need to consult other material prior to reading these chapters. Such problems certainly weaken the value of the volume as a handbook.

Volume 2 of *The Handbook of Econometrics* provides a highly referenced source of frontier topics in econometrics. Each chapter is well referenced for those seeking to explore topics in greater detail. However, all but the most technically sophisticated economists will find the book tough sledding, thereby reducing its value as a handbook. It will rarely be the first source one would consult, but it might prove a most important source if the reader is willing to work slowly through a particular chapter.

*The reviewer is a visiting economist with the Agriculture and Rural Economics Division, ERS.

Farm Equipment Innovations in Eastern and Central Southern Africa

Iftikhar Ahmed and Bill H. Kinsey (eds.). Brookfield, VT: Gower Publishing Co., 1984, 333 pp., $31.50.

Reviewed by Richard D. Sigwalt and Darryl S. Wills*

The problems facing agriculture in African nations today are not new. Low productivity, low incomes, and poor weather head the list of familiar problems confronting African farmers, the majority of whom are poor smallholders. One promising avenue for addressing these difficulties lies in the design of improved farm equipment. The editors of this volume set out to discover the current state of farm equipment use in smallholder agriculture and to assess the potential benefits of equipment innovations.

Bill Kinsey is considerably more than the editor of what is, in fact, a loosely structured argument for a systematic, multidisciplinary, and farm-centered approach to transforming peasant agriculture through appropriate technology. He has written four of the six case studies (those on Zambia, Tanzania, Uganda, and Malawi) and has coauthored three introductory and concluding chapters with Iftikhar Ahmed. Case studies on Kenya (by Gichuki Muchiri) and the southern Sudan (by J.D. de Coninck, A. Duncan, and P.E. Winter) and a substantial policy essay by Bruce R. Johnston round out the book.

The case studies are so disparate in theme and quality as to compromise the value of the book as a whole. Certainly the southern Sudan essay, which focuses heavily on how hand tools are supplied and which is based on no actual fieldwork in rural areas, belongs elsewhere. Kinsey's own essays are quite different from one another. The ones on Malawi, where he has worked extensively, and Zambia, where agriculture is already relatively highly mechanized, are particularly good; however, the one on Tanzania is based only on others' work and is far from thorough. Muchiri's piece differs considerably from the area surveys. Rather than surveying Kenya as a whole, Muchiri reports on an experimentation project with available technology with a view to later propagation; however the subject is germane because it exactly reflects the approach Kinsey, Ahmed, and Johnston favor.

From the case studies, the editors conclude that there has been no significant diffusion of new items of equipment for small farmers in East Africa in over two decades. One reason for this situation, they argue, is that past research and development (R&D) activity was both inadequate and inappropriate, operating without regard to what farmers really needed. The editors demonstrate conclusively that gasoline-driven equipment displaces laborers (presumably for urban unemployment), devours scarce capital, and falls into disuse in environments lacking an infrastructure to maintain such equipment. In every respect, they find animal-powered equipment preferable and believe that R&D should aim at inserting such equipment into local economies. An effective R&D program would have researchers study farms as social and economic systems and would identify what parts of those systems suffer constraints, especially seasonal labor constraints, that could be alleviated with improved farm equipment. Existing technology could then be applied to eliminate those particular bottlenecks.

The decision of the editors to include a chapter on policy considerations is wise because government actions not only detemine what types of R&D will be supported (and the extent of that support) but also foster the economic environment in which farmers must choose whether to adopt the results of that research. Even appropriate equipment innovations will not necessarily be adopted by farmers. Widespread acceptance depends on several factors, not the least of which is the price of the equipment relative to expected returns. Other factors include effective demonstration and training and a good transport and storage system to facilitate distribution. Overall government policies directly bear on these factors. Furthermore, Johnston emphasizes the desirability of designing equipment innovations that lend themselves to the creation and expansion of small-scale manufacturing in the countryside. Such a strategy would provide additional sources of employment and income and would expand the productive base of the economy, while conserving essential foreign reserves for other development needs.

One could easily fault the book for not addressing Africa's contemporary food crisis or for not placing it in its overall political and economic context. The case for appropriate technology is ably made (if it

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still has to be made); programmed innovation works only if it responds to needs and opportunities peasants themselves encounter in their workaday lives. Surely innovation would occur almost spontaneously, as it did in southern Africa a century ago, if peasants were offered attractive markets. If, as is clearly the case, peasants still need to be prodded into adopting improved equipment, why is that so?

Kinsey provides the beginning of an answer in his case study of Malawi. There, a simple winch-type gadget (the "Snail") costing about $700 was found to demand an amount for yearly operation about five times the average peasant's household income.[1] Kinsey finds that the only equipment a peasant has the income to purchase are hand tools such as the traditional hoe and machete. However valuable a farm-systems approach to development is (and it is valuable), it will lead nowhere until exploitation (through artificially low food prices) of the peasant to feed the city ends and until peasants are induced to invest by the simple promise of attractive gain. Until then, the farm-systems approach merely represents an attempt to reconcile technology and poverty.

[1]The Snail is a fuel-powered cultivating device designed to permit early planting and increase yields by facilitating the cultivation of dry, hard soils before the seasonal rains.

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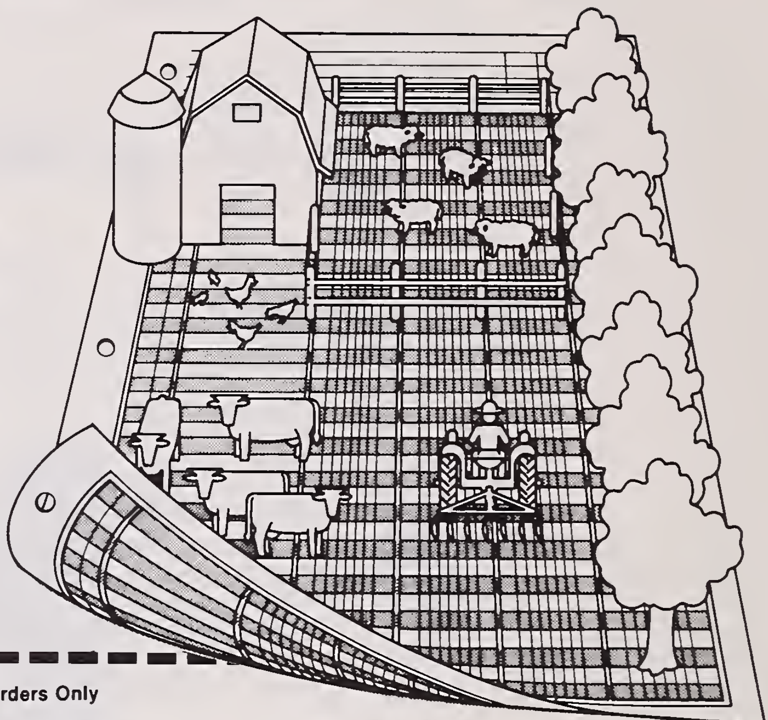

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